HEWLETT
PACKARD

OPERATION AND SERVICE MANUAL

MODEL 4145A

SEMICONDUCTOR PARAMETER ANALYZER

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 2149J- and above.

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SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This operation and service manual contains the information required to install, operate, test, adjust, and service the Hewlett-Packard Model 4145A Semiconductor Parameter Analyzer. Figure 1-1 shows the instrument and supplied accessories. This section covers specifications, instrument identification, description, options, accessories, and other basic information.

1-3. Listed on the title page of this manual is a microfiche part number that can be used to order 4 x 6 inch microfilm transparencies of the manual. Each microfiche contains up to 60 photo-duplicates of the manual pages. The microfiche package also includes the latest manual changes supplement as well as all pertinent service notes. To order an additional manual, use the part number listed on the title page of this manual.

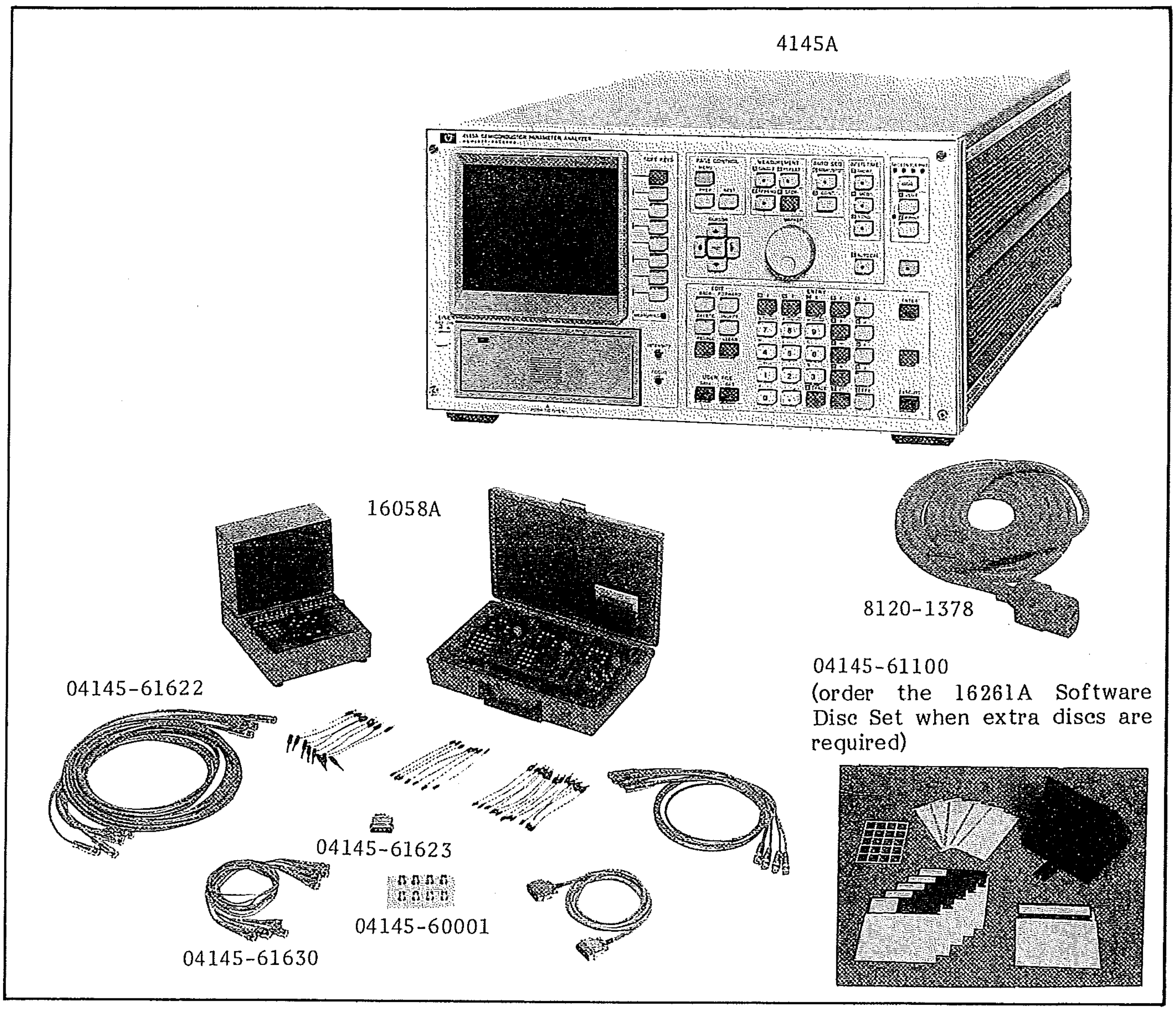


Figure 1-1. Model 4145A and Accessories.

1-4. DESCRIPTION

1-5. The Hewlett-Packard Model 4145A Semiconductor Parameter Analyzer is a fully automatic, high performance, programmable test instrument designed to measure, analyze, and graphically display the DC characteristics of a wide range of semiconductor devices, such as diodes, bipolar transistors, field-effect transistors, wafers, ICs, etc. Main applications include computer-aided design (CAD) of ICs, new device evaluation, materials evaluation, component selection for circuit design, incoming/outgoing inspection, semiconductor process control, quality control, and quality assurance. It is equipped with four programmable stimulus/measurement units (SMU), two programmable voltage source units (Vs), two voltage monitor units (Vm), a fully interactive graphics display, removable flexible-disc storage, softkeys, full arithmetic keyboard, and HP-IB. And it can be used on the bench or as part of a complete measurement system in the laboratory or on the production line.

1-6. For device stimulation and characteristics measurement, the 4145A has eight channels. Channels 1 through 4 are stimulus/measurement units (SMU); channels 5 and 6 are voltage source units (Vs); and channels 7 and 8 are voltage monitor units (Vm).

Each SMU channel has three modes of operation: voltage source/current monitor (V), current source/voltage monitor (I), and common (COM). Source voltage and source current can be held constant or swept linearly or logarithmically. When used as a voltage source/current monitor (V mode), each SMU can be programmed to output DC voltages from 0V to ±100V over three ranges--0V to ±19.999V, ±20V to ±39.998V, and ±40V to ±100V—with a resolution of 1mV, 2mV, and 5mV, respectively. When used as a current source/voltage monitor (I mode), each SMU can be programmed to output currents from ±1pA to ±100mA over nine ranges, with a resolution of 1pA max. (current measurement resolution is 50fA max.), depending on the current range. Current through the sample in V mode and voltage across the sample in I mode can be limited to prevent damage to the sample.

The two Vs channels are programmable voltage sources. Output voltage can be held constant or linearly or logarithmically swept from 0V to ±20V with 1mV resolution. The voltage sources are used when many bias and voltage sources are required.

Of the six source channels (four SMUs, two Vs), any combination of three can be automatically swept in a linear or logarithmic staircase manner within the range of each channel. Hold times from 0 to 650 seconds and delay times from 0 to 6.5 seconds can be programmed. In a multi-channel sweep setup, one channel functions as the main sweep channel. One of the other channels can be swept synchronously with the main channel, while one other channel can be swept subordinately to the main channel. SMUs not swept can be used as constant current or constant voltage sources.

The two Vm channels are used to measure voltages up to ±20V.

1-7. Measurement results, measurement setups, operator prompts, error messages, and diagnostics are displayed on a fully interactive, microprocessor based graphics display. Measurement results can be displayed in one of four modes : graphic, list, matrix, and schmoo. Front Panel softkeys provide a wide range of automatic display control functions, such as AUTO SCALE, STORE, RECALL, CURSOR, MARKER, vertical and horizontal ZOOM, LINE (two), GRAD, 1/GRAD, X intercept, Y intercept, and INTERPOLATE. Softkeys are used in all phases of instrument operation--from measurement setup to measurement analysis—and make overall instrument operation quick and easy.

By pressing the PLOT key or PRINT key, the presently displayed screen, whether a measurement result or measurement setup, can be dumped directly onto an HP-IB compatible printer/plotter, providing clear, inexpensive hard copies. The plot area is user selectable within the limits of the printer/plotter, and if a multi-pen plotter is used, multi-color plots can be made automatically. All PLOT and PRINT operations are done automatically, without a controller. Also, the 4145A's display is equipped with X-Y-Z outputs to allow connection of a large-screen graphics display.

The 4145A is fluent in HP-GL (Hewlett- Packard Graphics Language), permitting external control of its display via the HP-IB.

Cursor and marker positioning is user controllable via the front panel, and X-Y1-Y2 coordinates are digitally displayed on the CRT.

1-8. The 4145A is equipped with a flexible-disc drive unit that accommodates a single-sided, single-density, 13.3cm (5.25 in.), 92K byte disc. One cleaning disc and five work-discs—each containing the necessary operating system software, four general purpose measurement programs, and 36.6K bytes of user area—are furnished with the 4145A. Up to 47 measurement setup programs or 11 sets of measurement data, plus auto sequence programs, can be stored (SAVE) in the user area and recalled (GET) later. Additional discs can be purchased to increase storage capability, and the entire user area of each disc can be quickly copied.

1-9. All instrument functions are handled by a high speed microprocessor, under the control of the operating system software stored on each furnished flexible disc. Measurement setup, display mode selection, graphic scaling, diagnostics, operation guide, menu, and catalog are arranged as individual display pages. Paging is controlled by the MENU, PREV, and NEXT keys. Instructions, softkey labels, and error messages and codes are displayed on each page. Also, the 4145A is remotely controllable via the HP-IB and the 4145A's display can be used as an independent display via the HP-IB.

1-10. Furnished with the 4145A is the 16058A, a specially designed shielded test fixture which connects to the 4145A's rear panel. Eight different interchangeable DUT boards are provided, allowing measurement of diodes; 3-terminal and 4-terminal transistors; 8-pin, 10-pin, and 12-pin devices; and 18-pin and 24-pin DIP ICs. The 16058A is equipped with a light-shielded lid to allow stable measurement of light-sensitive devices, such as photo diodes, photo transistors, and photo resistors. Also, to insure operator safety when potentially dangerous voltages are applied to a sample, a warning will be displayed on the 4145A if the test fixture lid is open and measurement will not be made until the lid is closed. For user-fabricated test fixtures and jigs, a special connector, four 3-meter triaxial cables, and four 3-meter coaxial cables are also furnished.

1-11. SPECIFICATIONS

1-12. Complete specifications of the Model 4145A Semiconductor Parameter Analyzer are given in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested. The test procedures for the specifications are covered in Section IV, Performance Tests. Table 1-2 lists Reference Data. Reference Data are not specifications but are typical characteristics included as additional information for the operator. When the 4145A Semiconductor Parameter Analyzer is shipped from the factory, it meets the specifications listed in Table 1-1.

1-13. SAFETY CONSIDERATIONS

1-14. The Model 4145A Semiconductor Parameter Analyzer has been designed to conform to the safety requirements of an IEC (International Electromechanical Committee) Safety Class I instrument and is shipped from the factory in a safe condition.

1-15. This operation and service manual contains information, cautions, and warnings which must be followed by the user to ensure safe operation and to maintain the instrument in a safe condition.

1-16. INSTRUMENTS COVERED BY MANUAL

1-17. Hewlett-Packard uses a two-section nine character serial number which is stamped on the serial number plate (Figure 1-2) attached to the instrument's rear-panel. The first four digits and the letter are the serial prefix and the last five digits are the suffix. The letter placed between the two sections identifies the country where the instrument was manufactured. The prefix is the same for all identical instruments; it changes only when a change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument. The contents of this manual apply to instruments with the serial number prefix(es) listed under SERIAL NUMBERS on the title page.

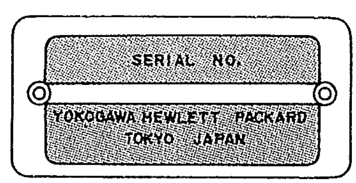


Figure 1-2. Serial Number Plate.

1-18. An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates the instrument is different from those described in this manual. The manual for this new instrument may be accompanied by a yellow Manual Changes supplement or have a different manual part number. This supplement contains "change information" that explains how to adapt the manual to the newer instrument.

1-19. In addition to change information, the supplement may contain information for correcting errors (called Errata) in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is identified with the manual print date and part number, both of which appear on the manual's title page. Complimentary copies of the supplement are available from Hewlett-Packard. If the serial prefix or number of an instrument is lower than that on the title page of this manual, see Section VII, Manual Changes.

1-20. For information concerning a serial number prefix that is not listed on the title page or in the Manual Change supplement, contact the nearest Hewlett-Packard office.

1-21. OPTIONS

1-22. Options are modifications to the standard instrument that implement the user's special requirements for minor functional changes. The 4145A has four options :

Option 907 : Front Handle Kit. Furnishes Carrying handles for both ends of front-panel.

Option 908 : Rack Frange Kit. Furnishes flanges for rack mounting for both ends of front-panel.

Option 909 : Rack Flange and Front Handle Kit. Furnishes both front handles and rack flanges for instrument.

Option 910 : An extra copy of the Operation and Service Manual.

Installation procedures for these options are given in Section II.

1-23. ACCESSORIES SUPPLIED

1-24. The Model 4145A Semiconductor Parameter Analyzer, along with its furnished accessories, is shown in Figure 1-1. The Additionally, a spare fuse (HP Part No. 2110-0015 or 2110-0305) and an Operation and Service Manual (HP Part No. 04145-90000) are furnished with the 4145A.

1-25. ACCESSORIES AVAILABLE

1-26. The Model 16261A Software Disc Set, containing five software discs, is available when extra discs are required.

1-27. Warranty Limitation for Accessories

1-28. The Personality Board (P/N: 16058-60003) and eight Boards (P/N: 16058-60004 through 16058-60011) furnished with the 16058A Test Fixture are warranted against defects in material and workmanship for a period of three months from the date of delivery. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace components which prove to be defective. This warranty does not apply to defects resulting from improper use or inadequate maintenance.

Table 1-1. Specifications (Sheet 1 of 8)

* Specifications listed below are for the 4145A only. For 16058A specifications, refer to the 16058A Operation Note.

GENERAL INFORMATION

Basic Functions : Measures the DC current through voltage-biased devices and the DC voltage across current-biased devices; Arithmetic calculation; Displays measurement results and calculation results on a built-in CRT display; graphics analysis capabilities; storage and recall of measurement setups, measurement data, and auto-sequence programs.

Source and Measurement Units :

Stimulus/Measurement Units (SMU) : Four SMU channels. Each SMU can be programmed to function as a variable or constant DC voltage source/current monitor or as a variable or constant DC current source/voltage monitor.

Voltage Sources (Vs) : Two Vs channels. Each Vs can be programmed to function as a variable or constant DC voltage source.

Voltage Monitors (Vm) : Two Vm channels. Each Vm can measure DC voltages up to ±20V.

SOURCE/MEASUREMENT FUNCTIONS

Measurement and output accuracies are specified at 23 °±5 °C after the instrument has been allowed to warm up for at least 40 minutes, with AUTO CAL set to ON, INTEG TIME set to SHORT and referenced to SMU common. Specified accuracy doubles for operation between 10 °C and 40 °C.

Stimulus/Measurements Units (SMU) : Four SMU channels. Each SMU measures current when operating as a voltage source, or measures voltage when operating as a current source. Source and measurement ranges, resolution, and accuracy specifications are given in the tables below.

Accuracy specifications in the below tables are given as ±n% of specified output or measured value, ±n% of range value. Io is output current (I), Vo is output voltage (V).

Voltage Range	Resolution	Accuracy	Max. Current
±20V	1mV	0.1%+0.05%+0.4Ω*Io	100mA
±40V	2mV		50mA
±100V	5mV		20mA

Table 1-1. Specifications (Sheet 2 of 8)

Current Range	Resolution	Accuracy	Max. Voltage
±100mA	100µA	0.3%+(0.1+0.2*Vo/100)%	20V (>50mA) 40V (>20mA)
±10mA	10µA		100V (≦20mA)
±1000µA	1µA		
±100µA	100nA		
±10µA	10nA		
±1000nA	1nA	0.5%+(0.1+0.2*Vo/100)%	
±100nA	100pA		
±10nA	10pA	1%+(0.1+0.2*Vo/100)%+5pA	
±1000pA	1pA		

Setting Resolution : Voltage, 4·1/2 digits (1mV max.); Current, 4 digits (1pA max.).

Measurement Resolution : Voltage, 4·1/2 digits (1mV max.); Current, 4 digits (50fA max.).

Ranging : Automatic.

Current/Voltage Limiting (Compliance) : Current output from an SMU operating as a voltage source and voltage output from an SMU operating as a current source can be limited.

Compliance Range : Current, 50pA to maximum allowable output current of each voltage range; Voltage, 0V to maximum allowable output voltage of each current range.

Accuracy: Current compliance, accuracy of current source+1% of range +10pA; Voltage compliance, accuracy of voltage source.

Residual Resistance (Voltage Source/Current Measurement Mode) : 0.4Ω.

Input Resistance (Current Source/Voltage Measurement Mode) : $\geqq 10^{12}\Omega$.

Capacitive Load : ≦1000pF.

Table 1-1. Specifications (Sheet 3 of 8)

Voltage Sources (Vs) : Two Vs channels. Each Vs can be programmed to function as a variable or constant DC voltage source. Output ranges, resolution, and accuracy specifications are given in the table below.

Output Voltage Range	Resolution	Accuracy	Max. Output Current
±20V	1mV	0.5% of setting +10mV	10mA

Output Impedance : Less than 0.2Ω

Capacitive Load : ≦1000pF

Voltage Monitors (Vm) : Two Vm channels. Output ranges, resolution, and accuracy specifications are given in the table below.

Measurement Voltage Range	Resolution	Accuracy
±2V	100μV	0.5% of reading + 10mV
±20V	1mV	0.2% of reading + 10mV

Input Impedance : 1MΩ±1%

Capacitance in Parallel with Output : 150pF±10%

Table 1-1. Specifications (Sheet 4 of 8)

SPECIFICATIONS COMMON TO ALL CHANNELS

Maximum Withstand Voltage : 100V (SMU, guard terminal, Vs, and Vm)

Maximum Voltage Between Common and GND : Less than ±42V.

Source Modes (SMUs Only) : V (voltage source/current monitor), I (current source/voltage monitor), and COM*.

Source Functions (SMUs Only) :
VAR1, staircase sweep;
VAR1', synchronous (VAR1) staircase sweep;
VAR2, subordinate (VAR1) staircase sweep;
CONST, constant source (voltage or current).

* : In COM mode, output voltage is 0V and compliance is 105mA.

Voltage/Current Sweep : Output from each SMU (voltage or current) and each Vs (voltage) can be swept by assigning source function VAR1, VAR1', or VAR2.

Max. Number of Steps : 512 in single-sweep measurements, up to 575 in multi-sweep measurements.

VAR1 : Main sweep. Linear or logarithmic sweep is selectable.

Linear Sweep : Staircase sweep in accordance with the user specified START, STOP, and STEP values.

Log Sweep : Staircase sweep in accordance with the user specified START and STOP values and selected LOG step (10, 25, or 50 points per decade).

VAR2 : Subordinate linear staircase sweep in accordance with the user specified START, STEP, an NO. OF STEPS values. VAR2 source channel output is incremeneted one STEP each time the VAR1 source channel completes one sweep.

VAR1' : Staircase sweep synchronized with the VAR1 sweep. Sweep is made with a user specified, fixed ratio or offset value. VAR1' output is calculated as :

VAR1' = a x VAR1 (fixed ratio)
VAR1' = b + VAR1 (fixed offset)

where "a" is the user-specified ratio (from ±0.01 to ±10) and "b" is the user-specified offset value. Ratio and offset must be such that the VAR1' source channel does not exceed its maximum output limit.

HOLD TIME : 0 to 650 seconds, 10ms resolution (max.). Accuracy is ±0.5%+9ms.

DELAY TIME : 0 to 6.5 seconds, 1ms resolution. Accuracy is ±0.1%+5xN for GRAPHICS and SCHMOO plots and ±0.1%+10xN for LIST and MATRIX displays. Where N is the number of measurement channels used in the measurement.

Output Sequence : The order in which the source channels begin output is fully programmable.

Measurement Modes : SINGLE, REPEAT, APPEND

Integration Time (at each measurement point) : SHORT, 3.6ms; MED, 20ms at 50Hz line frequency, 16.7ms at 60Hz line frequency; LONG, 16 times MED.

Table 1-1. Specifications (Sheet 5 of 8)

DISPLAY FUNCTIONS

Display : CRT. Electrostatic focus and deflection, post accelerated. Aluminized P-31 phosphor.

Screen Size : 16cm (6.25in) diagonal.
Screen Resolution : 2048 x 2048 points.

Display Characters and Symbols : Upper-case alphabetic characters, numerics, comma, (,), @ , Ω, ° (deg), ", %, # , q, k, e, m, μ, n, p, +, -, *, /, √ , Δ . All are entered from the front panel.

Display Modes : GRAPHICS, LIST, MATRIX, SCHMOO, and TIME DOMAIN.

GRAPHICS Display : Two-axes (X-Y) or three-axes (Y-Y_1-Y_2) plot of measured parameters and USER FUNCTION calculations.

LIST Display : Used in conjunction with VAR1 sweep. Up to six measurement parameters and USER FUNCTION results can be displayed for each step of the VAR1 source channel.

MATRIX Display : Used in conjunction with VAR1 and VAR2 sweeps. Up to six columns of sweep-dependent measurement results or USER FUNCTION results can be displayed.

SCHMOO Display : Used in conjunction with VAR1 and VAR2 sweeps. Sweep-dependent measurement results or calculation results are displayed on an X-Y-Z graph.

TIME DOMAIN Display : Measurement and calculation results are displayed on a two-axes (X-Y) or three-axes (X-Y_1-Y_2) graph as a function of time. VAR1 sweep is replaced by time.

Parameters : Initial Wait Time, 0 to 100 seconds (10ms resolution); Measurement Interval, 10ms to 10 seconds (10ms resolution); Number of Readings, 512.

Table 1-1. Specifications (Sheet 6 of 8)

ARITHMETIC AND ANALYSIS FUNCTIONS

Arithmetic Functions : Arithmetic expressions can be entered and executed directly from the front panel. Results are displayed on the CRT.

Arithmetic Operators : +, −, *, /, $\sqrt{\ }$, EXP (Napierian constant), LOG (common log), LN (natural log), ** (exponentiation), ABS (absolute), EEX (scientific notation), and Δ (differential calculation).

Keyboard Operation : Arithmetic expressions are executed by pressing the EXECUTE key. Results are displayed on the CRT.

USER FUNCTION : Up to two USER FUNCTION can be defined as arithmetic expressions. USER FUNCTIONS are executed during measurement and the results are displayed with measurement results.

Physical Constants : Three commonly used physical constants are permanently stored in memory. The stored value of each constant has seven-digit accuracy but only the five most significant digits are displayed.

q : Electron Charge, 1.602189×10^{-19} C
k : Boltzmann's Constant, 1.380662×10^{-23} J/°K
e : Dielectric Constant of vacuum, 8.854185×10^{-12} F/m.

Engineering Units : m (10^{-3}), μ (10^{-6}), n (10^{-9}), p (10^{-12})

Analysis Functions :

Overlay Graph Comparison : A GRAPHIC plot can be stored and later recalled to obtain an overlay comparison of two measurements. A SCHMOO plot can also be stored, but when the RECALL key is pressed, only the stored plot is displayed. Pressing RECALL a second time redisplays the previous plot. Only one set of data can be stored and scaling information is not included.

Auto Retrieve Function : Measurement data obtained in any display mode is automatically redisplayed whenever the display mode is changed. However, when the value of a measurement setup parameter is changed, all measurement data is cleared.

MARKER : On a GRAPHICS plot, the MARKER can be moved along a plotted curve or line. The X, Y_1 , and Y_2 coordinates at the MARKER location are digitally displayed on the CRT.

INTERPOLATE : Allows positioning of the MARKER between two measurement points. The X, Y_1, and Y_2 coordinates at the MARKER location are estimated and digitally displayed on the CRT.

CURSOR : On a GRAPHICS plot, the CURSOR is two intersecting and perpendicular lines which can be positioned at any point on the graph. There are two GRAPHICS cursors : LONG and SHORT. The X, Y_1, and Y_2 coordinates at the CURSOR location are digitally displayed on the CRT.

On a SCHMOO plot the CURSOR highlights the symbol at a measurement point and only the Z-axis value is digitally displayed on the CRT.

On LIST and MATRIX displays the CURSOR is a moveable pointer (►).

Table 1-1. Specifications (Sheet 7 of 8)

AUTO SCALE : GRAPHIC plots can be automatically rescaled after measurement, providing optimum display of measurement results.

ZOOM Function (←→, →←, ↑↓, ↓↑) : Used in conjunction with the CURSOR on GRAPHIC plots. Expands (←→, ↑↓) or contracts (→←, ↓↑) the graph in the indicated direction and in reference to the CURSOR location.

MOVE WINDOW : Repositions the LONG or SHORT CURSOR to the exact center of the plot area and moves displayed plots in reference to the CURSOR.

LINE : Draws a straight line between two moveable cursors. X and Y axes intercepts are digitally displayed, as are the line gradient (GRAD) and gradient reciprocal (1/GRAD) values.

MASUREMENT/DISPLAY SETUP AND STORAGE FUNCTIONS

Measurement/Display Setup : Interactive fill-in-the-blank programming of channel definitions, source outputs, and measurement/display modes.

Measurement Setup Storage : The existing measurement setup can be stored in the user-area on the flexible disc and recalled later by using the SAVE and GET keys, respectively.

Measurement Data Storage : The existing measurement results can be stored in the user-area on the flexible disc and recalled later by using the SAVE and GET key, respectively.

Auto-Sequence Program : A series of different measurements can be programmed for automatic execution. The maximum number of program steps is 24, and useable commands are GET, SINGLE, SAVE D, PLOT, PRINT, PAUSE, WAIT, and PAGE.

Storage Medium : 5.25 in. single-sided, single-density, soft-sectored mini flexible disc.

User-Area : 92K bytes.

Number of User Records : 131

Record Allocation : Measurement setup (file type P), 3 records;
Measurement data (file type D), 12 records;
Auto-sequence program (file type S), 1 record.

Table 1-1. Specifications (Sheet 8 of 8)

GENERAL SPECIFICATIONS

Data Input/Output :

External CRT Analog Output : From 0 to +1 Vdc, X and Y outputs (in series with approx. 330Ω) Z output (in series with approx. 240Ω), via rear panel BNC connectors. Frequency Bandwidth, DC - 2MHz.

External Plotter/Printer Output : Measurement data and all data appearing on the CRT may be output via the HP-IB to an HP plotter/printer operated in the LISTEN ONLY Mode. Output is initiated using the PLOT or PRINT key.

HP-GL Control : The CRT of the 4145A may be program controlled in the Graphics Display Mode via an HP-IB compatible Controller.

HP-IB and Remote-Control Functions : The 4145A may be interfaced to any HP controller or other instrument having HP-IB interface capability. (HP-IB is Hewlett-Packard's implementation of IEEE-488 and ANSI-MC.1.1 standards.)

Self-Test Function : At power ON, the 4145A automatically verifies its own operational status. HP-IB and DIAGNOSTICS page allow Self-Test to be performed at any time.

Operating Temperature Range: 10 °C to +40 °C; ≦70% RH (40 °C)
Permissible Temperature Change: ≦1 °C/5 min.;
Maximum Wet-bulb temperature : 29 °C

Power Requirements : 100/120/220V±10% : 240V -10% + 5%;
48 - 66Hz; Max. 270VA

Dimensions : 426W x 235H x 612D (mm) (approx.)

Weight : Approx. 27kg
Approx. 33kg (incuding accessories)

Table 1-2. Reference Data (Sheet 1 of 3)

REFERENCE DATA

(The following information is reference data only. It is not guaranteed specifications, nor does it include Test Fixture specifications.)

Measurement Time : (Response time + ranging time + integration time)/1 point measurement

Response Time : The following calculation is applicable where current range does not change (settling and set-up time + SMU wait time).

Current Range	Settling and Set-Up Time	SMU Wait Time
100nA - 100mA	2.7ms	0.2ms
1nA - 10nA		47.5ms

Ranging Time : 4ms - 74ms (depending on range)

Measurement Time : (Ranging time must be added.)

Settling and Set-Up Time	Delay Time	SMU Wait Time	Ranging Time	Integration Time
2.7ms	Setting Value	0.2ms or 47.5ms	4ms ~ 74ms	3.6ms ~ 320ms

Example : Minimum measurement time = 2.7ms + 0.2ms + 3.6ms = 6.5ms. In the Graphics Display Mode, write time (≧5.6ms) must be added.

Table 1-2. Reference Data (Sheet 2 of 3)

STIMULUS/MEASUREMENT UNIT (SMU)

Offset Current when operated as a Voltmeter : 6pA + 2pA x Vo/100

Offset Voltage when operated as a Current Meter : 10mV + 0.4Ω x Io

Noise Characteristics : (all values typical)
- Voltage Source Noise : 0.01% of range (RMS)
- Current Source Noise : 0.1% of range+3pA+0.01pAxCg (RMS)
  (Cg : Guard capacitance in pF)
- Voltage Monitor : 0.02% of range (peak-to-peak)
- Current Monitor : 0.3% of range + 10pA
  (peak-to-peak)

Output Overshoot : (all values typical)
- Voltage Source Overshoot : 5mV
- Current Source Overshoot : 1% or less

Current Range Switching Transient Noise : (All values typical)
- Range Increment : 0.01% of voltage range +10mV
- Range Decrement : When switching into 10nA or 1nA range, 10mV + 100/(10 + Cx)mV where Cx = load capacitance (pF); when switching into all other ranges, 10mV.

Guard Capacitance : ≦ 700pF

Guard Potential Offset : 1mV (typical)

Guard Current Induced Potential Error : 100ΩxIg (Ig = guard current)

Voltage Sources (Vs)
- Output Noise : 6 mVrms (typical)

Voltage Monitors (Vm)
- Noise Level : 0.3mVp-p at 2V-range (when Integration time is set to MED or LONG), 3mVp-p at 20V range.

REFERENCE DATA COMMON TO ALL UNITS

Noise Rejection : (Integration time set to MED or LONG.)

Normal Mode Rejection : ≧ 60dB (typical)

Common Mode Rejection : (all values typical)
- Current Source/Measurement : ≦ 1pA/1V

Table 1-2. Reference Data (Sheet 3 of 3)

ACCESSORIES FURNISHED WITH 4145A

16058A Test Fixture (includes the following subcomponents)

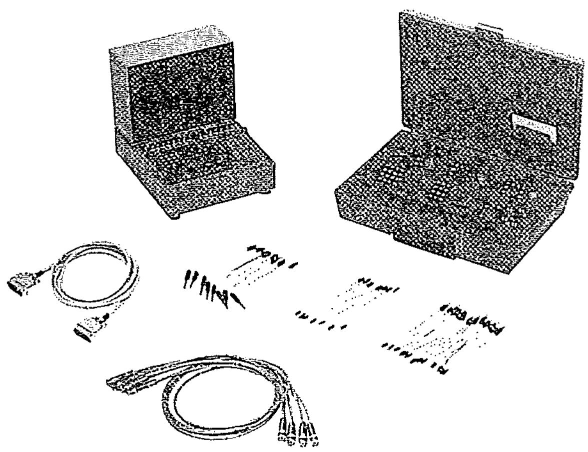
16058-60003	Personality Board
16058-60004	Teflon Blank Board
16058-60005	Socket Board (Transistor)
16058-60006	Socket Board (24-pin DIP)
16058-60007	Socket Board (18-pin DIP)
16058-60008	Socket Board (Diode)
16058-60009	Socket Board (8-pin package)
16058-60010	Socket Board (10-pin package)
16058-60011	Socket Board (12-pin package)
16058-61600	Connection Cable (large-to-small), 12 ea.
16058-61601	Connection Cable (small-to-small), 8 ea.
16058-61602	Miniature Clip Lead, 8 ea.
16058-61603	Triaxial Cable (1.5m), 4 ea.
16058-61604	Fixture System Cable
16058-60100	Accessory Case

04145-60001	Connector Plate
04145-61622	Triaxial Cable (3m), 4 ea.
04145-61630	BNC Cable (3m), 4 ea.
04145-61623	Shorting Connector
04145-61100	Software Discs (5 per box) (including P/N 9164-0168 Head Cleaning Disc)

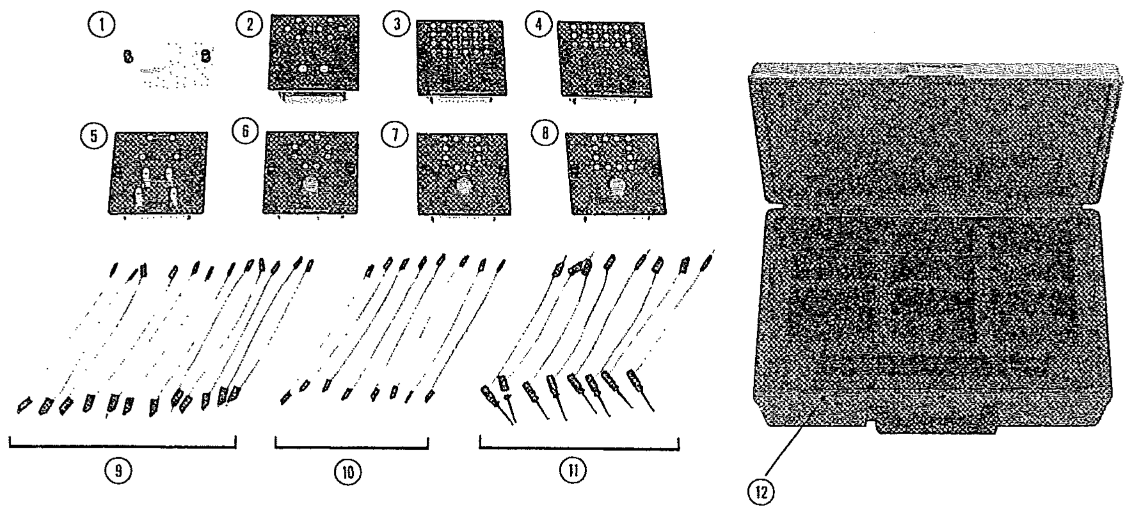
OPTIONS

Option 907 : Front Handle Kit (HP P/N 5061-0091)
Option 908 : Rack Flange Kit (HP P/N 5061-0079)
Option 909 : Rack and Handle Kit (HP P/N 5061-0085)
Option 910 : Extra Manual (HP P/N 04145-90000)

Table 1-3. Accessories Supplied (Sheet 1 of 5)

Configuration	Description
	16058A Test Fixture Shielded Test Fixture for measurement of discrete components. Equipped with safety lid. Following subcomponents are furnished with the 16058A. 16058-60003 Personality Board 16058-61603 Triaxial Cables, 1.5m, 4 ea. 16058-61604 System Cable Socket Board/Connection Cable Set* (Contents are shown below.)

* Socket Board/Connection Cable Set (included in the 16058A)



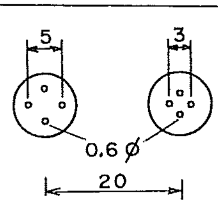
No.	Dimension of Socket (Unit in mm)	HP P/N and Description
1		Blank teflon board for measurement of high resistance devices.
2		Socket Board with two sockets. For measurement of four-pin devices, such as transistors.

Table 1-3. Accessories Supplied (Sheet 2 of 5)

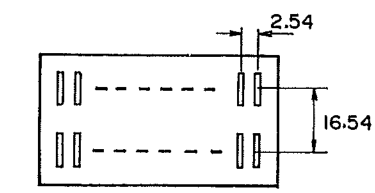
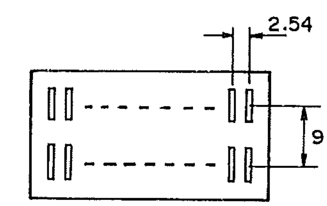
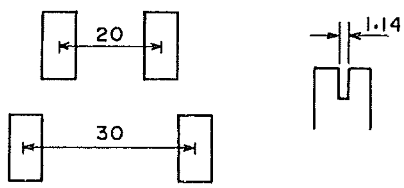
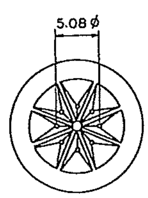
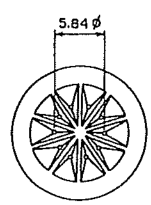
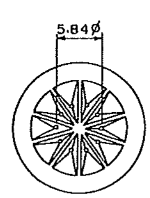
No.	Dimension of Socket (Unit in mm)	HP P/N and Description
3		16058-60006 : Socket Board for 24 pin DIP ICs.
4		16058-60007 : Socket Board for 18 pin DIP ICs.
5		16058-60008 : Socket Board with two pairs of sockets for measurement of axial lead devices such as diodes.
6		16058-60009 : Socket Board with an 8-pin socket.
7		16058-60010 : Socket Board with a 10-pin socket.
8		16058-60011 : Socket Board with a 12-pin socket.

Table 1-3. Accessories Supplied (Sheet 3 of 5)

No.	Dimension of Socket (Unit in mm)	HP P/N and Description
9	Cable length : Approx. 115	16058-61600 : Connection Cable (large-to-Small) used for interconnecting the Personality Board to the Socket Board. Twelve cables are furnished.
10	Cable length : Approx. 115	16058-61601 : Connection Cable (small-to-small) used for interconnecting the Connection Switch to the Socket Board. Eight cables are furnished.
11	Cable length : Approx. 115	16058-61602 : Miniature Clip Lead used for direct connection to DUT. Eight leads are furnished.
12		16058-60100 : Carrying-case for all 16058A accessories.

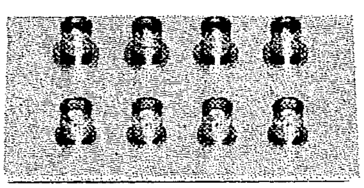
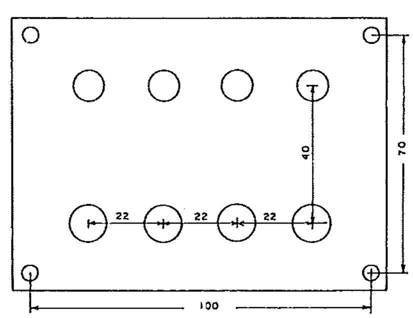
Configuration	Description
	Connector Plate (04145-60001) : Connector Plate for measurements made without the 16058A. For example, direct connection for a wafer probe. Dimensions are given below. 

Table 1-3. Accessories Supplied (Sheet 4 of 5)

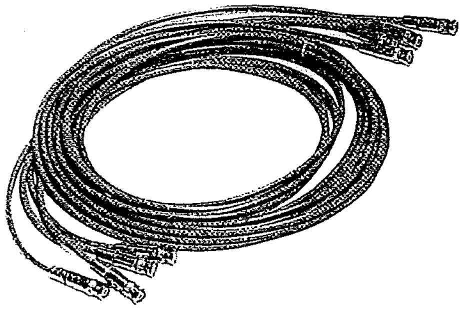
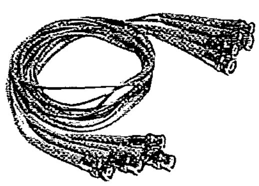
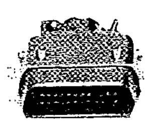
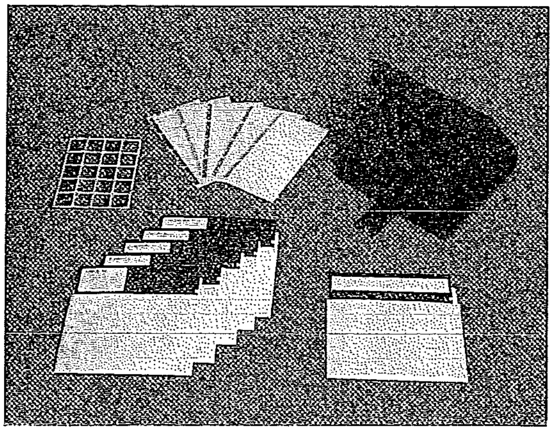
Configuration	Description
	Three-meter triaxial (m) Cable (04145-61622): Triaxial (m) cable for connection between the 4145A's SMU terminals and the Connector Plate. Cable length is 3m. Four cables are furnished. Refer to Figure 3-35 for the usage.
	Three-meter BNC (m) Cable (04145-61630): BNC (m) cable for connection between the 4145A's Vs or Vm terminals and the Connector Plate. Cable length is 3m. Four cables are furnished. Refer to Figure 3-35 for the usage.
	Shorting Connector (04145-61623): Allows SMU output voltage to exceed ±42V when the 16058A Test Fixture is not used. With the Shorting Connector connected to the System Cable connector on the rear panel, the instrument's fixture-lid-open detector is disabled, and the instrument assumes a fixture-lid-closed condition. WARNING A POTENTIAL SHOCK HAZARD EXISTS WHEN THE SHORTING CONNECTOR IS CONNECTED TO THE 4145A. DO NOT TOUCH THE OUTPUT TERMINAL OR INNER CONDUCTOR OF SMU DURING MEASUREMENT.

Table 1-3. Accessories Supplied (Sheet 5 of 5)

Configuration	Description
	Software Discs (04145-61100): Disc set includes 5 Software Discs, Cleaning Disc (P/N: 9164-0168), labels, and write-protect tabs. If extra discs are required, order the 16261A. Software Disc Set. It contains 5 software Discs. Note Software discs cannot be purchased individually.

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section provides installation instructions for the Model 4145A Semiconductor Parameter Analyzer. This section also includes information on initial inspection and damage claims, preparation for using the 4145A, and packaging, storage, and shipment.

2-3. INITIAL INSPECTION

2-4. The 4145A Semiconductor Parameter Analyzer, as shipped from the factory, meets all the specifications listed in Table 1-1. Upon receipt, inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1. The procedures for checking the general electrical operation are given in Section III (Paragraph 3-10 SELF TEST) and the procedures for checking the 4145A Semiconductor Parameter Analyzer against its specifications are given in Section IV. First, do the self test. If the 4145A is electrically questionable, then do the Performance Tests to determine whether the 4145A has failed or not.

If the contents are incomplete, if there is mechanical damage or defects (scratches, dents, broken switches, etc.), or if the performance does not meet the self test or performance tests, notify the nearest Hewlett-Packard office (see list at back of this manual). The HP office will arrange for repair or replacement without waiting for claim settlement.

2-5. PREPARATION FOR USE

2-6. POWER REQUIREMENTS

2-7. The 4145A requires a power source of 100, 120, 220 Volts ac $\pm 10\%$, or 240 Volts ac $+5\%$-10%, 48 to 66Hz single phase; power consumption is 270VA maximum.

WARNING

IF THE INSTRUMENT IS TO BE ENERGIZED VIA AN EXTERNAL AUTOTRANSFORMER UNIT FOR VOLTAGE REDUCTION, BE SURE THAT THE COMMON TERMINAL IS CONNECTED TO THE NEUTRAL POLE OF THE POWER SUPPLY.

2-8. Line Voltage and Fuse Selection

CAUTION

BEFORE TURNING THE 4145A LINE SWITCH TO ON, VERIFY THAT THE INSTRUMENT IS SET TO THE VOLTAGE OF THE POWER TO BE SUPPLIED.

2-9. Figure 2-1 provides instructions for line voltage and fuse selection. The line voltage selection switch and the proper fuse are factory installed for 100 or 120 volts ac operation.

CAUTION

USE PROPER FUSE FOR LINE VOLTAGE SELECTED.

CAUTION

MAKE SURE THAT ONLY FUSES FOR THE REQUIRED RATED CURRENT AND OF THE SPECIFIED TYPE ARE USED FOR REPLACEMENT. THE USE OF MENDED FUSES AND THE SHORT-CIRCUITING OF FUSEHOLDERS MUST BE AVOIDED.

2-10. LINE FREQUENCY FILTER

2-11. To reject the effects of line-frequency noise, set the FILTER switch on the rear panel to the frequency of the ac power source.

2-12. POWER CABLE

2-13. To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that the instrument panel and cabinet be grounded. The Model 4145A is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable is the ground wire.

2-14. To preserve the protection feature when operating the instrument from a two contact outlet, use a three prong to two prong adapter (HP Part No. 1251-0048) and connect the green pigtail on the adapter to power line ground.

CAUTION

THE MAINS PLUG MUST ONLY BE INSERTED IN A SOCKET OUTLET PROVIDED WITH A PROTECTIVE EARTH CONTACT. THE PROTECTIVE ACTION MUST NOT BE NEGATED BY THE USE OF AN EXTENSION CORD (POWER CABLE) WITHOUT PROTECTIVE CONDUCTOR (GROUNDING).

2-15. Figure 2-2 shows the available power cords, which may be used in various countries including the standard power cord furnished with the instrument. HP Part number, applicable standards for power plug, power cord color, electrical characteristics and countries using each power cord are listed in the figure. If assistance is needed for selecting the correct power cable, contact the nearest Hewlett-Packard office.

2-16. OPERATING ENVIRONMENT

2-17. Temperature. The instrument may be operated in temperatures from +10°C to +40°C.

2-18. Humidity. The instrument may be operated in environments with relative humidities to 70% at 40°C. However, the instrument should be protected from temperature extremes which cause condensation within the instrument.

2-19. INSTALLATION INSTRUCTIONS

2-20. The HP Model 4145A can be operated on the bench or in a rack mount. The 4145A is ready for bench operation as shipped from the factory. For bench operation a two-leg instrument stand is used. For use, the instrument stands are designed to be pulled towards the front of instrument.

2-21. Installation of Options 907, 908 and 909.

2-22. The 4145A can be installed in a rack and be operated as a component of a measurement system. Rack mounting information for the 4145A is presented in Figure 2-3.

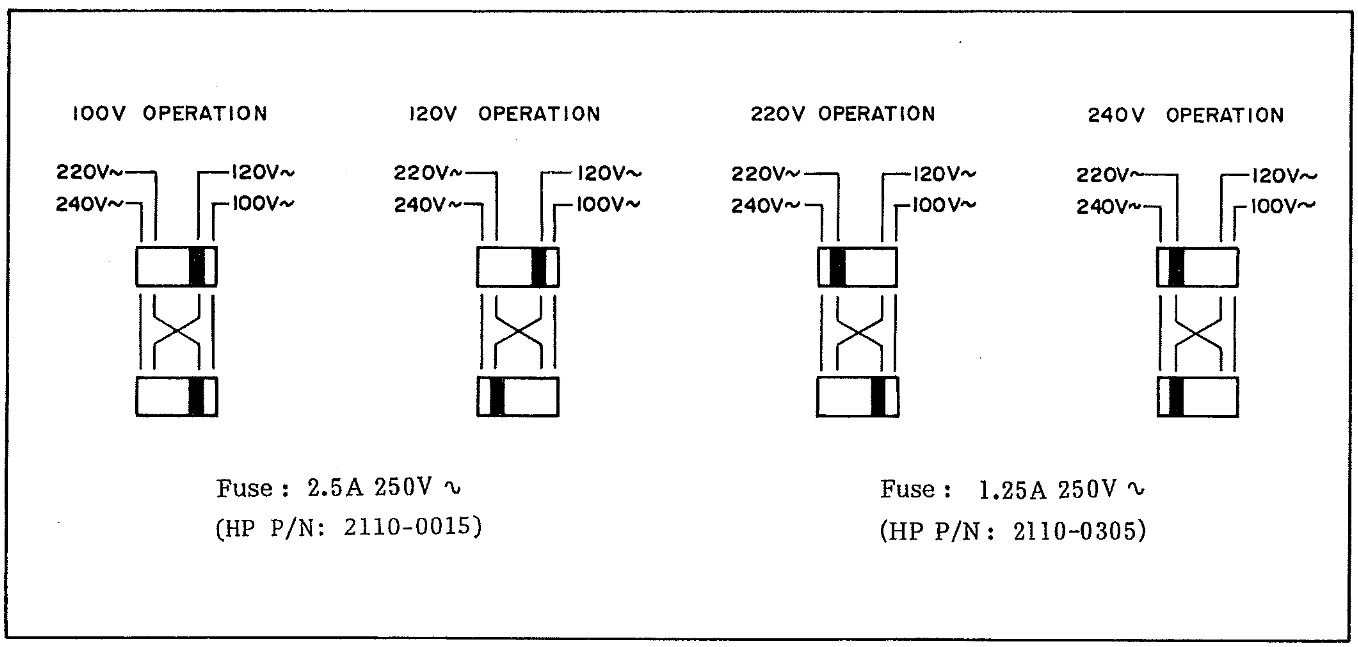
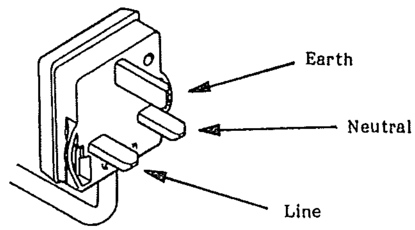


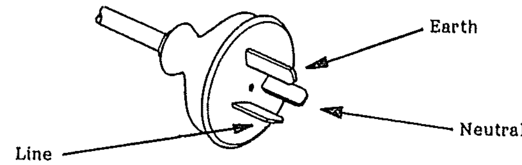
Figure 2-1. Voltage and Fuse Selection.

OPTION 900 — United Kingdom



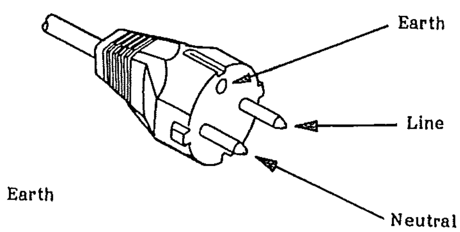
Plug : BS 1363A, 250V
Cable : HP 8120-1703

OPTION 901 — Australia/New Zealand



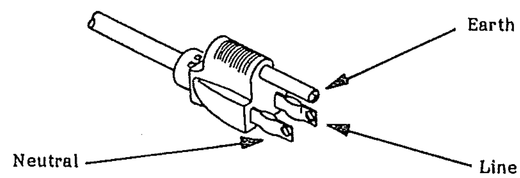
Plug : NZSS 198/AS C112, 250V
Cable : HP 8120-0696

OPTION 902 — European Continent



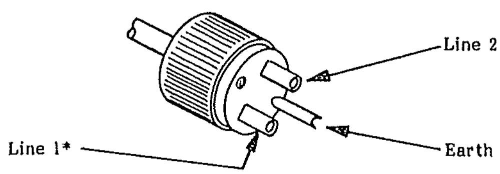
Plug : CEE-VII, 250V
Cable : HP 8120-1692

OPTION 903 — U.S./Canada



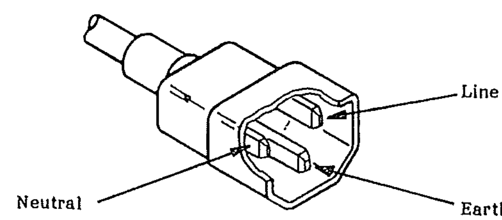
Plug : NEMA 5-15P, 125V, 15A
Cable : HP 8120-1521

OPTION 904 — U.S./Canada



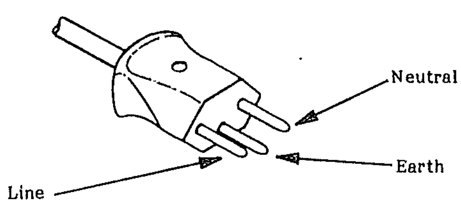
Plug : NEMA 6-15P, 250V, 6A
Cable : HP 8120-0698

OPTION 905** — Any country



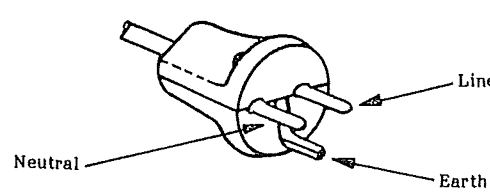
Plug : CEE 22-VI, 250V
Cable : HP 8120-1860

OPTION 906 — Switzerland



Plug : SEV 1011.1959-24507 Type 12, 250V
Cable : HP 8120-2104

OPTION 912 — Denmark



Plug : DHCR 107, 220V
Cable : HP 8120-2956

NOTE : Each option number includes a ' family ' of cords and connectors of various materials and plug body configurations (straight, 90 ° etc.).

* In the U.S.A. a 230-volt mains might not include a neutral conductor. In this case it is recommended that the blue conductor of the standard power cord be connected to the terminal normally used for neutral (line 1).

Figure 2-2. Power Cables Supplied.

2-23. STORAGE AND SHIPMENT

2-24. ENVIRONMENT

2-25. The instrument may be stored or shipped in environments within the following limits:

Storage:

Temperature .... -22 °C to +55 °C
(+4 °C to +50 °C with discs)

Humidity .... 8% to 80% (RH)

Shipment :

Temperature .... -40 °C to +62 °C
(-40 °C to +50 °C with discs)

Humidity .... 8% to 80% (RH)

The instrument should be protected from temperature extremes which cause condensation inside the instrument.

2-26. PACKAGING

2-27. Original Packaging. Containers and materials identical to those used in factory packaging are available from Hewlett-Packard. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number, and full serial number. Also mark the container FRAGILE to assure careful handling. In any correspondence, refer to the instrument by model number and full serial number.

2-28. Other Packaging. The following general instructions should be used for re-packing with commercially available materials:

a. Wrap instrument in heavy paper or plastic. If shipping to Hewlett-Packard office or service center, attach tag indicating type of service required, return address, model number, and full serial number.

b. Use strong shipping container. A double-wall carton made of 350 pound test material is adequate.

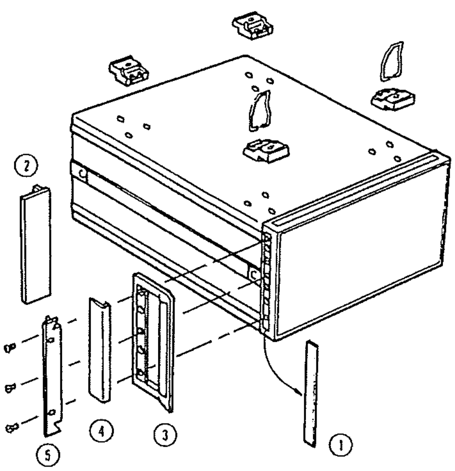
c. Use enough shock absorbing material (3 to 4 inch layer) around all sides of instrument to provide firm cushion and prevent movement inside container. Protect control panel with cardboard.

d. Seal shipping container securely.

e. Mark shipping container FRAGILE to ensure careful handling.

f. In any correspondence, refer to instrument by model number and full serial number.

Option	Kit Part Number	Parts Included	Part Number	Q'ty	Remarks
907	Handle Kit 5061-0091	Front Handle Trim Strip X8-32 x 3/8 Screw	(3) 5060-9901 (4) 5020-8898 2510-0195	2 2 6	 9.525mm
908	Rack Flange Kit 5061-0079	Rack Mount Flange X8-32 x 3/8 Screw	(2) 5020-8864 2510-0193	2 6	 9.525mm
909	Rack Flange & Handle Kit 5061-0085	Front handle Rack Mount Flange X8-32 x 3/8 Screw	(3) 5060-9901 (5) 5020-8876 2510-0194	2 2 6	 15.875mm



1. Remove adhesive-backed trim strips (1) from side at right and left front of instrument.
2. HANDLE INSTALLATION : Attach front handle (3) to sides at right and left front of instrument with screws provided and attach trim (4) to handle.
3. RACK MOUNTING : Attach rack mount flange (2) to sides at right and left front of instrument with screws provided.
4. HANDLE AND RACK MOUNTING : Attach front handle (3) and rack mount flange (5) together to sides at right and left front of instrument with screws provided.
5. When rack mounting (3 and 4 above), remove all four feet (lift bar at inner side of foot, and slide foot toward the bar).

Figure 2-3. Rack Mount Kit.

SECTION III
OPERATION

3-1. INTRODUCTION

3-2. This section provides all the information necessary to operate the Model 4145A Semiconductor Parameter Analyzer. Included are descriptions of the front and rear panels, graphics display, lamps, and connectors; discussions on operating procedures and measuring techniques for typical applications; and instructions on the instruments self-test function and HP-IB capabilities. A breakdown of the contents of this section is given in Figure 3-1. Warnings and cautions are given throughout; they must be observed to insure operator safety and continued instrument serviceability.

WARNING

BEFORE THE INSTRUMENT IS TURNED ON, ALL PROTECTIVE EARTH TERMINALS, EXTENSION CORDS, AUTO-TRANSFORMERS AND DEVICES CONNECTED TO THE INSTRUMENT MUST BE CONNECTED TO A PROTECTIVE EARTH-GROUNDED SOCKET. ANY INTERRUPTION OF THE PROTECTIVE EARTH GROUNDING WILL CAUSE A POTENTIAL SHOCK HAZARD THAT COULD RESULT IN SERIOUS PERSONAL INJURY.

ONLY FUSES OF THE REQUIRED RATED CURRENT AND OF THE SPECIFIED TYPE SHOULD BE USED. DO NOT USE REPAIRED FUSES OR SHORTED FUSEHOLDERS. TO DO SO CAN CAUSE A SHOCK OR FIRE HAZARD.

CAUTION

BEFORE THE INSTRUMENT IS TURNED ON, IT MUST BE SET TO THE VOLTAGE OF THE POWER SOURCE (MAINS), OR DAMAGE TO THE INSTRUMENT MAY RESULT.

Basic Operation
(paragraphs 3-3 through 3-39)

↓

Graphics Display
(paragraphs 3-40 through 3-76)

↓

Measurement Basics
(paragraphs 3-77 through 3-89)

↓

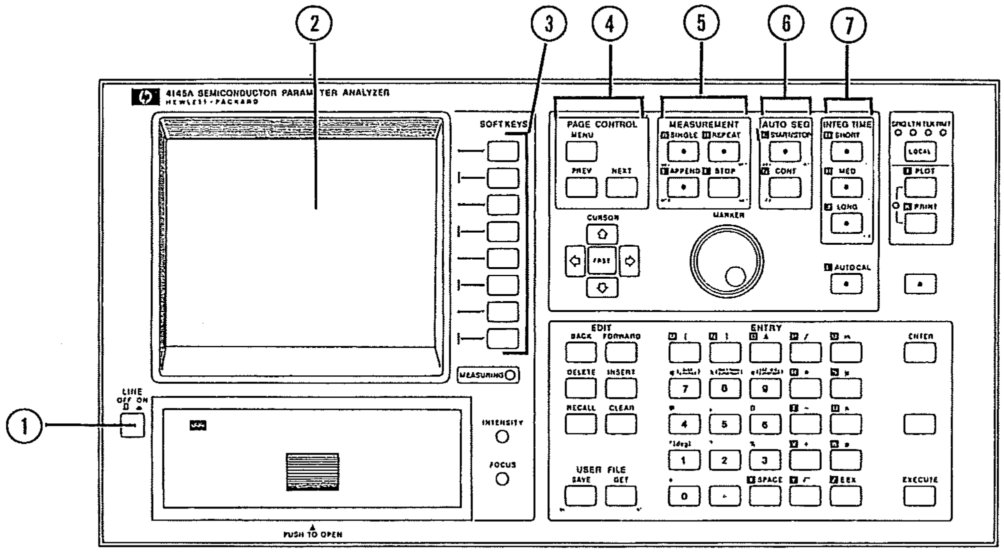
Extended Capabilities
(paragraphs 3-90 through 3-126)

* HP-IB Capabilities
* PLOT Function
* PRINT Function
* External Display
* Disc Copy
* Head Cleaning

Figure 3-1. Contents of Section III.

3-3. PANEL FEATURES

3-4. The front and rear panels of the 4145A are briefly described in Figures 3-2 and 3-3, respectively. Detailed information is given starting in paragraph 3-5.



① LINE ON/OFF:

Applies ac line power to the instrument when set to the ON (▄) position. Removes ac line power when set to the OFF (█) position. SELF TEST is performed each time the instrument is turned on. After SELF TEST is performed, the start-up MENU is displayed.

② CRT DISPLAY:

Displays all measurement setups, measurement results, softkey labels, special user functions, operator messages, error codes and messages, and warnings. All displays can be dumped directly onto an HP-IB plotter, without a controller, by pressing the PLOT key ⑨ . If an HP-IB controller, fluent in HP-GL (Hewlett-Packard Graphics Language), is connected, the CRT can be used as an independent graphics display. Refer to paragraph 3-103 and 3-107 for details.

③ SOFTKEYS:

These eight keys are used for measurement setup, parameter selection, and function selection. The function of each softkey is defined by the operating system software and changes depending on the page displayed. Softkeys labels are displayed on the CRT ② in the form of a "softkey prompt" (SKP). Each time the SKP changes, the functions of the corresponding softkey changes. Pressing the EXTN (extended) displays additional softkey functions. A description for each softkey function is provided in the description of the page on which it appears.

④ PAGE CONTROL Keys:

These three keys control paging on the CRT ② . Refer to paragraph 3-40 for a description of the PAGE concept.

MENU: When pressed, returns the display to the start-up menu. Can be used anytime except during measurement or auto-calibration or other functioning.

Figure 3-2. Front Panel Features (Sheet 1 of 6).

NEXT: Advances the display to the next page. Each time this key is pressed, the instrument checks the presently displayed page for any illegal settings, and if it detects any errors, it displays the corresponding error message and does not advance to the next page, or automatically changes the settings.

PREV: Returns the display to the previous page. Each time this key is pressed, the instrument checks the presently displayed page for any illegal settings.

⑤ MEASUREMENT Keys:

These keys start and stop the measurement. After all measurement conditions have been set and the GRAPHICS PLOT page, LIST DISPLAY page, MATRIX DISPLAY page, or SCHMOO PLOT page is displayed, measurement is started by pressing SINGLE, REPEAT, or APPEND. Measurement can be stopped by pressing STOP. Measurement is a sequential operation consisting of voltage or current sweep, measurement, and storage of the measurement result.

SINGLE: When this key is pressed, results of the previous measurement are erased from memory, the new measurement is made, and the results are stored in memory.

REPEAT: When this key is pressed, measurement is repeatedly made until STOP is pressed. Results of the previous measurement are updated during each new measurement.

APPEND: Functions similarly to the SINGLE key except that results of the previous measurement are not erased from memory of the CRT. Results of a measurement made using this key are stored in the remaining unused portion of memory and are displayed over (overlay plot) the previous plot. Measurement can be made using this key until "Buffer full" is displayed.

STOP: Immediately stops the measurements.

⑥ AUTO SEQ Key:

These keys start and stop the ASP (Auto Sequence Program) listed on the SETUP AUTO SEQUENCE page. Refer to paragraph 3-61 for details on Auto Sequence Programs.

START/STOP: Starts the ASP from line 1. If pressed during the ASP, the ASP stops immediately. Once stopped, the ASP cannot be continued from the stop point.

CONT: If the ASP contains a PAUSE statement, this key continues the program from the line immediately following the PAUSE statement.

⑦ INTEG TIME Keys:

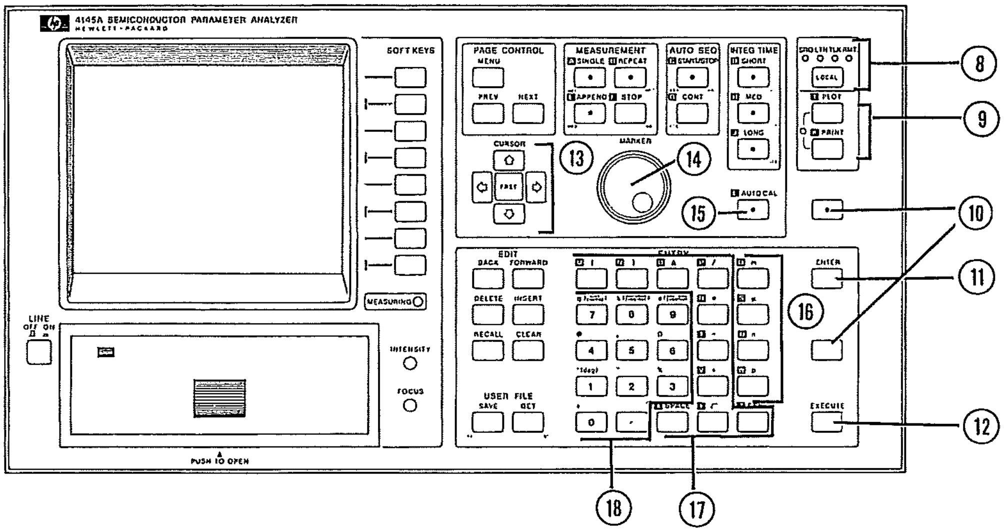
These keys are used to select the digital integration time. When MED or LONG integration is selected, the integration time is an integral number of the line frequency period, eliminating line frequency noise. SHORT is the initial control setting. The integration time can be changed at any time, even during measurement.

SHORT: Measurement data is stored directly into memory without integration.

MED: Integration time is set to one line frequency period. Sixteen samples are taken at each measurement point.

LONG: Integration time is set to sixteen line frequency periods. A total of 256 samples are taken at each measurement point.

Figure 3-2. Front Panel Features (Sheet 2 of 6).



(8) HP-IB Status Indicators and LOCAL Key :

These four LED lamps—SRQ, LISTEN, TALK, and REMOTE—indicate the status of the 4145A when interfaced with a controller via the HP-IB, or connected directly to a printer/plotter. The LOCAL key, when pressed, releases the 4145A from remote (HP-IB) control and enables control from the front panel. The LOCAL key does not function when the instrument is set to local lockout by the controller or in the GL mode.

(9) PLOT and PRINT Keys

The PLOT key is used to dump whatever is displayed on the CRT directly onto an HP-IB plotter (e.g., HP9872C), without a controller. Plot area can be set from the 4145A's front panel. Plotting starts when EXECUTE is pressed. Pressing PLOT a second time stops the plot immediately. Refer to paragraph 3-117 for more information on the PLOT function. The PRINT key functions similarly to the PLOT key except that a printer is used instead of a plotter and only alphanumeric data is output. If the PRINT key is used to output the results of a graphic plot, for example, only the numeric value of each measurement point is printed. Refer to paragraph 3-119 for more information on the PRINT function.

(10) BLUE Key and GREEN Key :

These keys are used to access additional key functions. Additional key functions are labeled in blue and green.

BLUE Key : This key is used when entering comments, variables, and program names. Once this key is pressed (key indicator lamp on), it remains on until pressed again. When the CHANNEL DEFINITION page is displayed or when a SAVE/GET operation, COMMENT operation or PURGE operation is being performed, the BLUE key is automatically set to ON (key indicator lamp on).

GREEN Key : This key is used when entering physical constants and certain special symbols. It is valid for one key-in operation only; that is, it must be pressed each time a green-labeled key function is desired.

Figure 3-2. Front Panel Features (Sheet 3 of 6).

(11) ENTER Key:

This key is used to enter parameter values, alphanumeric characters, special characters, and unit indicators displayed on the Keyboard Input Line (see Figure 3-5) into the internal display buffer. When this key is pressed, data displayed on the Keyboard Input Line is moved to the display field indicated by the field pointer (▶) and stored in the display buffer. Data stored in the display buffer by the ENTER key can be recalled (re-displayed on the Keyboard Input Line) by pressing the RECALL Key (19). Up to 60 characters can be entered into the buffer, but only 27 characters can be displayed at one time. To display the rest of the buffer contents, use the BACK key or FORWARD key.

(12) EXECUTE Key:

This key executes GET, SAVE, PRINT, PLOT, PURGE, and REPACK commands, and arithmetic expressions displayed on the Keyboard Input Line.

Note: The PURGE and REPACK commands are available only when the USER FILE CATALOG is displayed.

(13) CURSOR Control Keys:

These keys control the positioning of the field pointer (▶) and the long and short cursors. (They do not control the cursor on the Keyboard Input Line.)

Field Pointer Control:
Pressing the ⇧, ⇩, ⇦, or ⇨ key moves the field pointer (▶) in the indicated direction. The FAST key cannot be used for field pointer control.

Long/Short Cursor Control:
Pressing the ⇧, ⇩, ⇦, or ⇨ key moves the cursor in the indicated direction. Movement continues until the key is released. Two direction-keys can be pressed simultaneously to move the cursor diagonally. Pressing the FAST key in conjunction with one or two of the direction keys, causes the cursor to move more rapidly.

(14) MARKER Control Dial:

This dial controls the marker (◎ or *) on the GRAPHICS PLOT page. Rotating the dial clockwise moves the marker from the sweep start point to the sweep stop point.

(15) AUTO CAL KEY:

This key enables continuous auto-calibration of the 4145A. The AUTO CAL function is set to ON (key indicator lamp on) when the instrument is turned on. Refer to paragraph 3-37 for details.

(16), (17), (18) DATA ENTRY Keys:

These keys are used to enter numeric values, arithmetic operators, and engineering units. Data entered with these keys is displayed on the CRT's Keyboard Input Line and entered into the display buffer by pressing the ENTER key (11). An arithmetic expression entered with these keys is executed by pressing the EXECUTE key.

(16) Engineering Unit Keys:

Four engineering units are available—m (milli, 10^{-3}), μ (micro, 10^{-6}), n (nano, 10^{-9}), and p (pico, 10^{-12})—for use with the numeric keys (18).

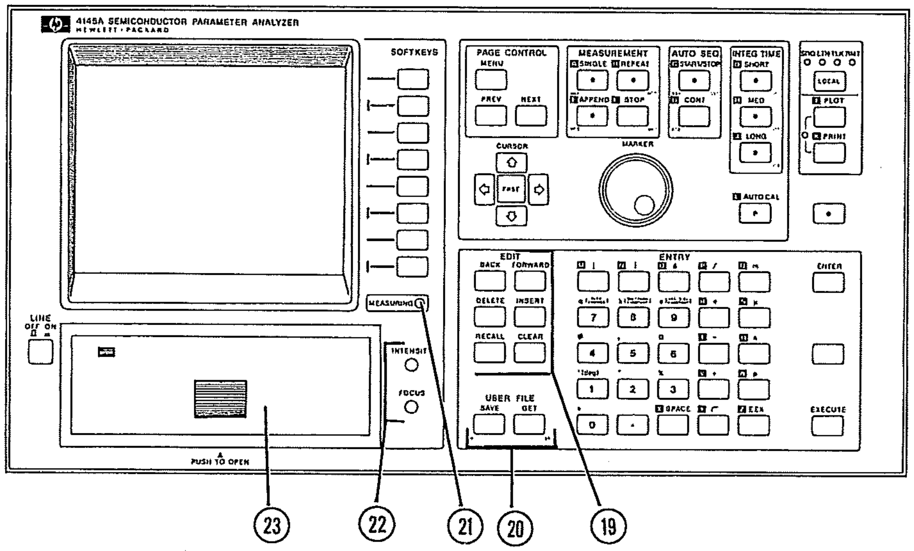
(17) Arithmetic Operator and Function Keys:

Nine arithmetic operators and functions are available—+, -, *, /, $\sqrt{\ }$, Δ, (,), EEX (scientific notation)—for use in arithmetic calculations. Five additional operator and functions are available with the alphabetic (blue) keys : ** (exponentiation), LOG, LN (natural log), EXP (natural base), and ABS (absolute). The SPACE key is also included in this key group.

(18) Numeric Keys:

These keys—0 through 9 and decimal point—are used for entering measurement parameter values and for making quick arithmetic calculations.

Figure 3-2. Front Panel Features (Sheet 4 of 6).



19 EDIT Keys:

These keys are used to edit data displayed on the Keyboard Input Line.

BACK: Moves the Keyboard Input Line cursor (_) left one position. If this key is pressed while the cursor is at the left-most position, the displayed text will move to the right.

FORWARD: Moves the Keyboard Input Line cursor (_) right one position. If this key is pressed while the cursor is at the right-most position, the displayed text will move to the left.

DELETE: Causes the character at the position of the cursor to be deleted. The cursor remains at the same position and all text to the right of the deleted character moves one position to the left as each character is deleted.

INSERT: Causes the character at the position of the cursor and all text to the right of the cursor to move right one position, leaving a space at the position of the cursor and allowing insertion of additional characters. To exit from this mode, press INSERT a second time.

RECALL: Causes previous entries or executions to be re-displayed on the Keyboard Input Line.

CLEAR: Clears all text from the Keyboard Input Line and returns the cursor to the home (left-most) position.

Figure 3-2. Front Panel Features (Sheet 5 of 6).

(20) USER FILE Keys:

These keys are used to store program or data files onto the disc or to recall them.

SAVE: Used to store the existing measurement setup, measurement result, or auto-sequence program onto the flexible disc. Press SAVE, enter the file type (P for a measurement setup, D for a measurement result, S for an auto-sequence program), file name, and comment (if necessary), and then press EXECUTE (12).

GET: Used to recall a measurement setup, measurement result, or auto-sequence program from the flexible disc. Press GET, enter the file type (P for a measurement setup, D for a measurement result, S for an auto-sequence program), and file name, and then press EXECUTE (12).

(21) MEASURING Lamp:

This lamp comes on when the 4145A is measuring. When measurement is completed or when the STOP key is pressed, this lamp goes off immediately.

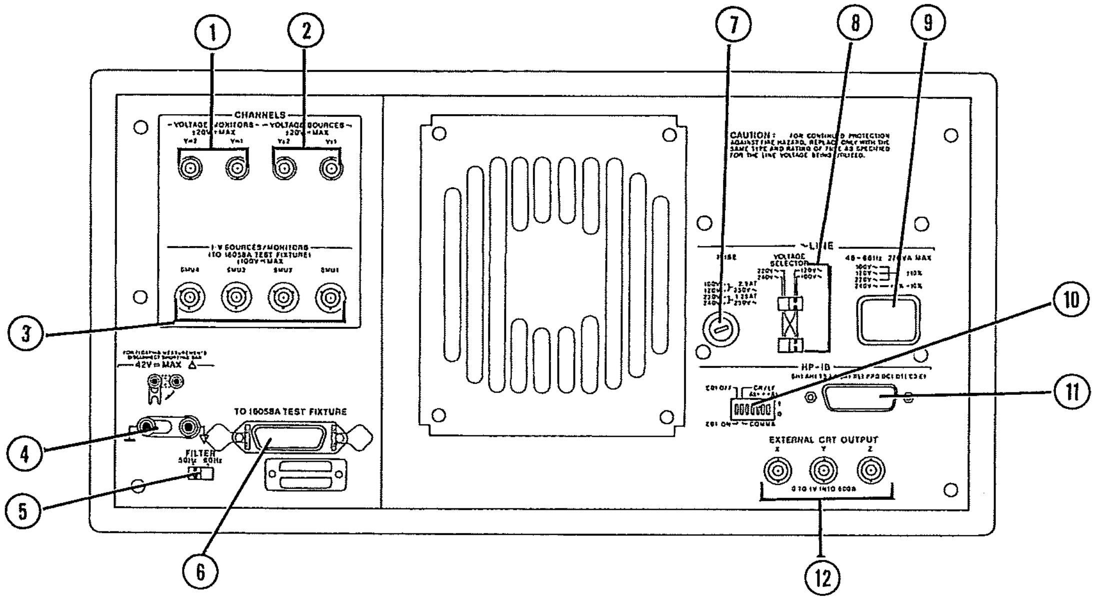
(22) CRT Adjustment:

INTENSITY determines the brightness of traces displayed on the CRT. FOCUS adjusts the writing beam for sharp, well-defined traces.

(23) FLEXIBLE DISC DRIVE:

Accommodates a 92K byte, single-sided, single-density, 5·1/4 inch flexible disc, and functions as the 4145A's mass storage unit (MSU). The lamp, located in the upper left-hand corner of the drive unit door, comes on when the 4145A is reading data from the disc. To open the door, press firmly on the center of the door until an audible click is heard, then release the door. Refer to paragraph 3-5 for information on proper handling of the flexible disc.

Figure 3-2. Front Panel Features (Sheet 6 of 6).



(1) Voltage Monitor (Vm) Input Connectors:

Two female BNC connectors for input to Vm1 and Vm2. Used in applications in which a user-fabricated test fixture is used. These connectors cannot be connected to the 16058A Test Fixture. Maximum allowable input voltage is ±20V dc.

(2) Voltage Source (Vs) Output Connectors:

Two female BNC connectors for Vs1 and Vs2. Used in applications in which a user-fabricated test fixture is used. These connectors cannot be connected to the 16058A Test Fixture. Maximum output voltage is ±20V dc.

(3) SMU Output Connectors:

Four triaxial connectors for SMU1 through 4. Can be connected to the 16058A Test Fixture or to a user-fabricated test fixture. Each connector outputs or measures up to ±100V or ±100mA.

(4) COM (COMMON)-GROUND Terminals:

Common (∇) and Ground ($\perp$) for floating and grounded measurements. The common terminal is tied directly to the outer-conductor of the Vm (1), Vs (2), and SMU (3) connectors; the ground terminal is tied directly to the instrument chassis. For grounded measurements, these terminals must be interconnected using the shorting-bar. For floating measurements, disconnect the shorting-bar.

WARNING

A POTENTIAL SHOCK HAZARD MAY EXIST WHEN COMMON IS NOT CONNECTED TO GROUND (SHORTING-BAR DISCONNECTED). DO NOT, REGARDLESS OF THE OUTPUT VOLTAGE, TOUCH THE COMMON TERMINAL OR OUTER CONDUCTOR OF THE SMU, Vs, OR Vm CONNECTORS DURING A FLOATING MEASUREMENT (SHORTING-BAR DISCONNECTED).

Figure 3-3. Rear Panel Features (Sheet 1 of 2).

⑤ FILTER Switch :

This switch determines the measurement integration time, to reduce the effects of line-frequency noise. Set this switch to the frequency of the ac power source.

⑥ System Cable Connector :

Twenty-four pin connector for inter-connection between the 16058A Test Fixture and the 4145A. Vs1, Vs2, Vm1, Vm2, and the fixture-lid-open detector are connected to this connector. When the 16058A is not used, this connector should be terminated with the furnished shorting-termination if voltages exceeding ±42V are to be output.

WARNING

WHEN THE SHORTING-TERMINATION IS CONNECTED TO THE SYSTEM CABLE CONNECTOR, THE 4145A'S PROTECTIVE CIRCUIT IS DISABLED. VOLTAGES AT THE SMU AND Vs OUTPUTS CAN REACH ±100V AND ±20V, RESPECTIVELY. DO NOT TOUCH THE POINT OR POINTS AT WHICH THE SMU'S OR VOLTAGE SOURCES ARE CONNECTED.

⑦ LINE FUSE Holder :

The 4145A's power-line fuse is installed in this holder.

100V/120V operation :
2.5AT, 250V (HP P/N : 2110-0015)

200V/240V operation :
1.25AT, 250V (HP P/N : 2110-0305)

⑧ LINE VOLTAGE SELECTOR Switches

These switches select the appropriate ac operating voltage. Selectable voltages are 100V/120V±10% and 220V±10% / 240V+5% -10% (48 - 66Hz). Refer to paragraph 2-5.

⑨ LINE Input Receptacle :

AC power cable is connected to this receptacle. Refer to paragraph 2-5.

⑩ HP-IB Control Switch :

This switch sets the 4145A's HP-IB address (0 - 30), data output format (COMMA or CR/LF), and interface capability (EOI ON or OFF). Specific information on this switch is given in paragraph 3-97.

⑪ HP-IB Connector :

Twenty-four pin connector; connects the 4145A to the HP-IB for remote operations. Also used to connect a printer/plotter.

⑫ External CRT Output Connectors :

Three BNC (f) connectors for connection to an external X-Y-Z display. Refer to paragraph 3-121.

Figure 3-3. Rear Panel Features (Sheet 2 of 2).

3-5. FLEXIBLE DISC HANDLING

3-6. Five work-discs and one head-cleaning disc are furnished with the 4145A. Each work-disc contains the required operating system software, four general purpose measurement setups, and 33.5K bytes of user area. Installation and removal procedures for the disc are shown in Figure 3-4. Precautions on handling and storing the flexible discs are given below.

1. When not in use, each disc should be placed in its own outer jacket. Exposed areas of the disc should be completely covered by the jacket.
2. Store discs in an upright position. Do not stack or pile discs.
3. Store discs in a clean, dry, fireproof cabinet. Do not expose to direct sunlight, extremes of temperature or humidity, or magnetic fields.
4. Do not touch the exposed surface of the disc.
5. Do not apply strong pressure to the protective jacket. When labelling a disc, use a felt-tip pen. Do not use a pencil or ball-point pen.
6. Do not bend the discs.

CAUTION

DO NOT INSERT ANYTHING OTHER THAN FLEXIBLE DISCS INTO THE DISC DRIVE.

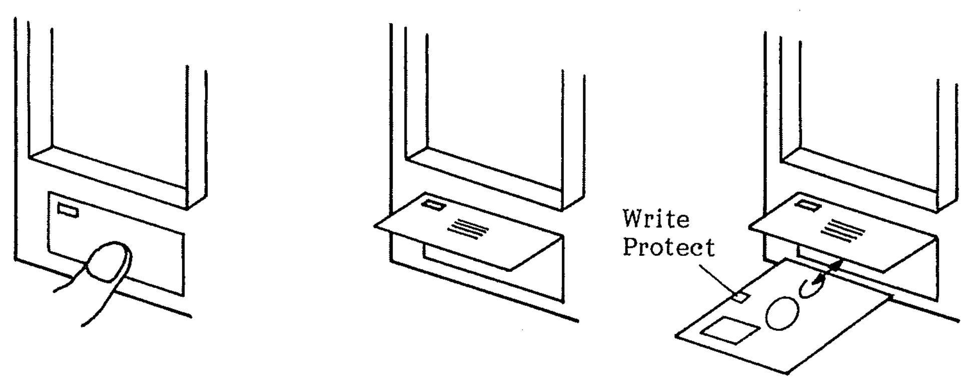
Note

Use only the discs furnished with the 4145A.

3-7. CRT DISPLAY

3-8. The 4145A is equipped with the HP Model 1345A Digital Display. For complete information on the 1345A, refer to the 1345A Operation and Service Manual, included in this binder.

3-9. Useable display area on the CRT is shown in Figure 3-5. Operator adjustments are given in Figure 3-6.



(a) Push firmly and release.

(b) Door opens.

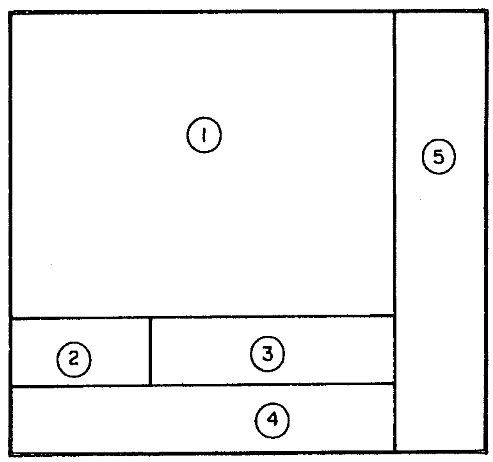
(c) Carefully insert or remove the disc.

(d) Push the door until clicks.

Note :

Fully insert the disc into the disc drive before closing the disc drive door.

Figure 3-4. Disc Installation and Removal.



The CRT is sectioned into five areas, as shown in the figure. Description for each area is as follows :

(1) Page Display Area :
The instrument's various pages are displayed in this area. When the PLOT key is pressed, only this area is output to the plotter.

(2) Command Display Area :
The SAVE, GET, PLOT, PRINT, PURGE and REPACK commands are displayed in this area.

(3) Keyboard Input Line :
All keyboard (front panel) entries are displayed in this area. Up to 60 characters can be entered but only 27 can be displayed. To edit the displayed characters, use the BACK, FORWARD, DELETE and INSERT keys. When the RECALL key is pressed, the previous entry is re-displayed.

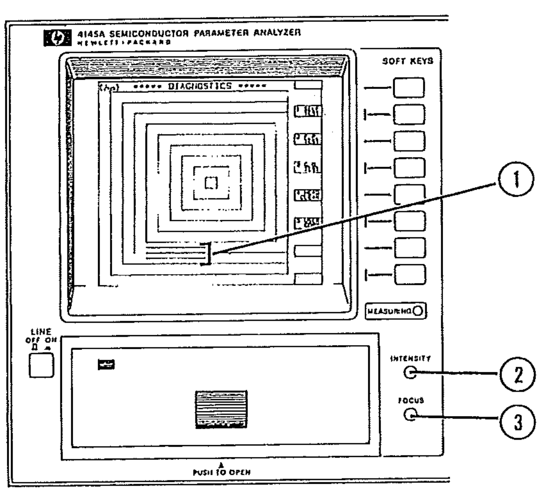
(4) System Message Line :
Displays instructions, error messages, and error codes. When the instrument is turned on, instrument status is displayed.

(5) Softkey Prompt Display Area :
Displays Softkey Prompts (SKP).

Note

(2), (3), and (4) are erased by pressing the CLEAR key.

Figure 3-5. Useable Display Area.



CRT intensity and focus adjustment. (Requires a small flat-tip screwdriver.)

(1) Turn on the 4145A. The MENU page will be displayed on the CRT.

(2) Press the EXTN softkey and the DIAG softkey.

(3) Press the GDU TEST softkey. Display will be as shown in the figure.

(4) Adjust INTENSITY (2) until all three lines (each line has a different intensity) are visible. ((1))

(5) Adjust FOCUS (3) until the corners of the displayed trace are sharp.

(6) Press the MENU key.

Figure 3-6. Operator Adjustment.

3-10. SELF TEST

3-11. The 4145A is equipped with an automatic self-diagnostic function that is initiated each time the instrument is turned on to confirm normal operation of the instrument's basic functions. The SELF TEST can also be initiated from the DIAGNOSTICS page or via the HP-IB. When SELF TEST is performed at instrument turn-on, the five tests listed in Table 3-1 are automatically performed. If the instrument is operating normally, the MENU page will be displayed when the SELF TEST is completed. If an error is detected, an error code will be displayed on the CRT. When SELF TEST is initiated from the DIAGNOSTICS page or via the HP-IB, only two tests are performed (MPU test and SMU test). If the instrument fails the SELF TEST, contact the nearest Hewlett-Packard Service Office (see list at back of this manual).

3-12. ERROR MESSAGES/ERROR CODES

3-13. Error messages and error codes are displayed on the System Message Line of the CRT whenever an illegal operation or out-of-range measurement is made, or whenever an internal circuit fails. Error messages and error codes related to operator errors (not instrument failure) are listed in Table 3-2 and 3-3, respectively. Error codes related to instrument failure are listed in Table 3-4. If the instrument displays one of the error codes listed in Table 3-4, contact the nearest Hewlett-Packard Sales/Service Office.

Note

One of the error codes listed in Table 3-4 may be displayed if the instrument is turned on after experiencing an extreme change of ambient temperature. In this case, allow the instrument to fully warm up (ignore the displayed error code), and then turn it off and on one time.

Table 3-1. 4145A SELF TEST

Test Name	Description
MPU test	Checks the basic functions of the MPU (Microprocessor Unit) by checking four ROMs (Read-Only Memory) and sixteen RAMs (Randam-Access Memory).
GDU test	Checks the functions of the GDU (Graphics Display Unit).
MSU test	Checks the MSU (Mass Storage Unit : Flexible Disc Drive and Disc).
HP-IB test	Checks all HP-IB interface capabilities.
SMU test	Checks the basic functions of the four SMUs.

Table 3-2. Error Messages (Sheet 1 of 2)

Error Message	Meaning	Corrective Action
No source name	An SMU that has been assigned a source mode (COM, V, or I) has not been assigned a corresponding V or I source name.	If the source mode is COM or V, enter a source name in the V column; if the source mode is I, enter a source name in the I column.
Duplicate name	Two or more channels have the same name.	Re-assign the channel names.
Illegal function	VAR1, VAR1', or VAR2 is specified more than once.	Specify VAR1, VAR1', and VAR2 only once.
	VAR1 and VAR1' are not in the same source mode.	Set VAR1 and VAR1' to the same source mode.
Overflow	Number of steps for VAR1 exceeds 512.	Change the value of START/STOP or STEP.
	An attempt was made to input a value that is outside specified limits.	Enter a value that is within specified limits.
No name	No name is entered in the NAME field on the MEAS/DISP MODE SETUP page.	Select a name from those displayed in the softkey prompt area.
No monitor channel	No monitor channel name is entered in the NAME field on the MEAS/DISP MODE SETUP page, or the name entered in the NAME field cannot be used as a monitor channel name.	Select a monitor channel name from those displayed in the softkey prompt area.
Illegal setup	LOG Sweep: (Display) START and STOP (MIN and MAX) values have different signs.	Change one of the signs.
	Current value is too high because source mode has been changed from V to I.	Change the current (I) value setting.
	INTERVAL or NO. OF RDNGS for a time domain measurement is set to 0.	Enter correct value : Up to 10s for INTERVAL and from 1 to 512 for NO. OF RDNGS.
	Duplications on the OUTPUT SEQUENCE SETUP page.	Rearrange the output sequence.
Buffer full	Measurement data exceeds the capacity of the data buffer.	Data buffer capacity is 512 measurement points for a single sweep, or up to 575 (depends on the number of monitor channels used, VAR2 steps and the number of times APPEND is used) in other cases.

Table 3-2. Error Messages (Sheet 2 of 2)

Error Message	Meaning	Corrective Action
Syntax error	An illegal name was entered in a GET or SAVE command.	The first character of a file name must be alphabetic, and all succeeding characters must be alphanumeric.
	PLOT area is not specified, contains one or more alphabetic characters, or is missing coordinate delimiters (comma or space).	Re-enter the PLOT area correctly.
	Illegal file type.	Use P, D, or S for the file type.
Busy	Auto calibration is being performed.	Auto calibration is performed every 5 minutes.
No data	PRINT Key was pressed with no measurement data in the data buffer.	Perform a measurement.
Printer/ Plotter is not connected	No printer or plotter is connected to the instrument, or the printer or plotter is not set to LISTEN.	Connect the printer or plotter.
Not compatible	The discs used in the copy operation have different system labels, or one of the discs is not a 4145A useable disc.	Copy cannot be performed.
Close the fixture lid	The fixture lid is open at the start of a measurement in which the output voltage may exceed ±42V or lid is open during the User Mode (See Fig. 39).	Close the lid or change the setup. Make sure the system cable is properly connected.
Output disabled, close the fixture lid	The fixture lid was opened during a measurement in which the output voltage may exceed ±42V.	Close the fixture lid and make the measurement again. Do not open the fixture lid during measurement. Make sure the system cable is properly connected.
Emergency	Output was shut down to prevent SMU damage.	Make sure the setup and all connections are correct.
Recovered from power down	Indicates that there was a momentary power loss.	When a power loss occurs during measurement, output is shut down. Press MEASUREMENT key to continue the measurement.
Step overflow	NO OF STEPS for VAR1 exceeds 512.	Change START value, STOP value, or STEP value.
Disabled function	A disabled softkey was pressed.	The softkey cannot be used in the existing measurement setup.

Table 3-3. Operational Error-Codes (Sheet 1 of 2)

Display	Meaning
Error E01	Arithmetic operator (-, +, /, *) or parenthesis is required.
Error E02	EXECUTE was pressed with no executable text on the Keyboard Input Line.
Error E03	Object buffer overflow.
Error E04	Improper Δ (delta) operation.
Error E05	User function is used in the expression. (User function cannot be used in an arithmetic expression.)
Error E06	No variable or constant following an arithmetic operator.
Error E07	Arithmetic expression contains an undefined variable.
Error E08	Too many signs or parentheses.
Error E09	Constant value is too large.
Error I01	Stack Register overflow.
Error I02	Improper calculation was attempted. For example, the divisor is zero.
Error I03	Insufficient Δ data.
Error M02	Disc is not inserted or is not correctly inserted.
Error M03	The disc is write protected.
Error M04	Illegal file name or file type.
Error M05	The file name specified in the SAVE command has already been reserved for the specified file type.
Error M06	Number of total files exceeds 96.
Error M07	Number of total records exceeds 131.
Error M08	User area may be lost. Copy immediately onto another disc.
Error M19	The disc was not initialized for the 4145A.
Error Z01	The program specified by the GET command in the auto-sequence program contains an error. Press CONT to perform the next step of the auto-sequence program.
Error Z02	The SINGLE command can be executed from the GRAPHICS, MATRIX, LIST, or SCHMOO page only. Press CONT to perform the next step of the auto-sequence program.
Error Z03	PLOT or PRINT was performed by the auto-sequence program but no printer/plotter is connected to the 4145A or the printer/plotter is not set to LISTEN. Press CONT to perform the next step of the auto- sequence program.

Table 3-3. Operational Error-Codes (Sheet 2 of 2)

Display	Meaning
Error Z04	The test fixture lid is open during an auto-sequence program in which the output voltage may exceed ±42V. Press CONT to perform the next step of the auto- sequence program.
Data Errors	Depending on the number of channels used in the measurement, up to six 2-digit numbers are displayed, in the format shown below, whenever the measurement cannot be performed correctly. Error DXX XX XX XX XX XX Here, XX is a 2-digit number which represents channel status. The left-to-right order in which the 2-digit error codes appear corresponds to the order in which the channels are assigned on the MEAS/DISP MODE SETUP page. Also, the number of 2-digit error codes that appear is identical to the number of channels used in the measurement. The left digit of XX is hexadecimal and must be converted into a 4-digit binary number, as described below. The right digit is decimal and requires no conversion. Also, zero means no error. XX 1 : Stack register overflow 2 : Calculation error 3 : Insufficient data for Δ measurement 7 : Undefined user-function 8 : INTERVAL in a time domain measurement is too short. Complete measurement data cannot be stored before the next measurement begins. Convert hexadecimal number into binary. A/D converter saturated. Oscillation Other channel has reached compliance limit. This channel has reached compliance limit. Channel correspondence is shown below : GRAPHICS PLOT: Error DXX XX XX X axis Y1 axis Y2 axis LIST DISPLAY: Error DXX XX XX XX XX XX 1st 2nd 3rd 4th 5th 6th MATRIX DISPLAY, SCHMOO PLOT: Error DXX

Table 3-4. Hardware-Related Error-Codes

Display	Meaning
Error P01 - P04	One of the four ROMs (Read Only Memory) is not functioning properly.
P05 - P20	One of the sixteen RAMs (Ramdom Access Memory) is not functioning properly.
P21	MPU's (Microprocessor Unit) peripheral circuit is not functioning properly.
M08 - M18	MSU (Mass Storage Unit : Flexible Disc and drive) is not functioning properly. Try another disc.
A01	SMU controller is not functioning properly.
CHAN (!!!DOWN!!!)	
CHAN (XX,XX,XX,XX)	SMU itself is not functioning properly. (XX indicates the SMU number and error code. Refer to Fig. 3-20.)

Note

If a momentary power loss occurs, the 4145A's display may go blank. To recover, turn off the instrument, wait a few seconds, and then turn on the instrument.

3-14. INITIAL CONTROL SETTINGS

3-15. To facilitate operation, the instrument is automatically set to the following initial control settings each time it is turned on :

Front Panel Controls :

MEASUREMENT keys	OFF
AUTO SEQ key	OFF
INTEG TIME keys	SHORT
PLOT/PRINT keys	OFF
AUTO CAL key	ON
BLUE key	OFF

Internal Setup :

CRT Display	MENU Page
Measurement Program	GENL (see note)
PLOT Area .... (for external plotter)	Previously specified values

Note

Each flexible disc contains four different application programs, of which GENL is one. Refer to paragraph 3-87 for details on the furnished applications programs.

All data stored on the disc is retained; that is, the disc is not erased when the instrument is turned off.

3-16. USER-AREA FILING OPERATIONS

3-17. The 4145A uses a 5.25 inch, single-sided, single-density flexible disc as the storage medium for its MSU (mass storage unit). Each of the five work-discs furnished with the 4145A contains the necessary operating system software, four general purpose measurement programs, and enough user area for 131 records. Up to 96 files can be stored in the user-area.

Note

A record is the minimum unit for storage on the disc. A file consists of 1, 3, or 12 records, depending on the file type.

Three types of files can be stored in the user-area :

1. Measurement program files—file type P : Specifying file type P in the SAVE command reserves 3 records on the disc and stores the existing measurement setup (channel assignments, parameter settings, graphic scaling, output sequence, etc.) at the reserved 3-record location.

2. Measurement data files—file type D : Specifying file type D in the SAVE command reserves 12 records on the disc and stores the measurement setup and measurement results (GRAPHICS, LIST, MATRIX, or SCHMOO) at the reserved 12-record location.

3. Auto-sequence program files—file type S : Specifying file type S in the SAVE command reserves 1 record on the disc and stores the existing auto-sequence program at the reserved 1-record location.

For more information on file types, number of records used, etc., refer to Figure 3-30, 4145A FILE CATALOG Page.

Four filing operations—SAVE, GET, PURGE, and REPACK—can be performed from the front panel. Each is described below :

SAVE :

Used to store the existing measurement setup (except INTEG TIME, AUTO CAL, and softkey functions), the existing auto-sequence program, output sequence setup, or the measurement results. SAVE cannot be used when the disc is write-protected. Before saving a measurement setup, a page check must be performed (refer to para. 3-44). To SAVE a file, press the SAVE key (SAVE will appear on the Keyboard Input Line of the CRT) and input the file type (P, D, or S) and file name. The file name can contain up to six characters, of which the first must be alphabetic and the last five must be alphanumeric.

GET :

Used to recall user-stored files from the disc. GET cannot be used to recall any of the furnished measurement programs. To GET a file from the user-area of the disc, press the GET key (GET will appear on the Keyboard Input Line of the CRT) and input the file type (P, D, or S) and file name.

PURGE:

Used to delete user-stored files from the disc. PURGE cannot be used with a write-protected disc, nor can it be used to delete any of the furnished measurement programs. It is available only when the 4145A FILE CATALOG page is displayed. To PURGE a file from the user-area of the disc, go to the MENU and select CAT softkey. When the 4145A FILE CATALOG page appears on the display, press the PURGE softkey (PURGE will appear on the Keyboard Input Line of the CRT) and input the file type (P, D, or S) and file name. DO NOT turn off the instrument during PURGE.

REPACK:

Used to repack all files stored in the user-area of the disc. REPACK cannot be used when the disc is write-protected, and is available only when the 4145A FILE CATALOG page is displayed. To REPACK the user-area, go to the MENU and select CAT softkey. When the 4145A FILE CATALOG page appears on the display, press the REPACK softkey (REPACK will appear on the Keyboard Input Line of the CRT) and then press EXECUTE.

SAVE, GET, PURGE, and REPACK cannot be input using the alphabetic keys and can be used for user-area filing operations only. No filing operations can be performed on the operating system software or the furnished applications programs.

3-18. ARITHMETIC CAPABILITIES

3-19. Arithmetic operations that can be performed on the 4145A are listed in Table 3-5. To perform an arithmetic operation, first key in the expression (it will appear on the display as you do so), then press EXECUTE. The result will be displayed on the Keyboard Input Line of the CRT in a floating decimal format (scientific notation).

Example: $\sqrt{\ }$ 2 + 1

Key strokes: $\boxed{\sqrt{\ }}$ $\boxed{2}$ $\boxed{+}$ $\boxed{1}$ $\boxed{\text{EXECUTE}}$

Displayed Result: 2.4142E+00

Results of arithmetic operations are always displayed in scientific notation consisting of a 5-digit base and 2-digit exponent, regardless of the expression's complexity. Thus, if 1+2 is executed, the result is displayed as 3.0000E+00. Also, the exponent is always a multiple of three, regardless of the exponent used in the original expression. For example, if 1E+07 is executed, the result is displayed as 10.000E+06. The decimal point is always positioned so that the exponent is a multiple of three.

Results are always rounded before being displayed if they contain more than 5 digits. The first excess digit is checked, and if its value is 6 or greater, the digit to the left (the fifth digit) is incremented (rounded up) by one; if its value is 5 or less, the fifth digit is unchanged. For example, executing 1+1.00001 will result in 2.0000E+00, but executing 1+1.00006 will result in 2.0001E+00.

Table 3-5. Arithmetic Operators

Sign	Name	Example	
		Equation	Key Strokes
+	Addition	5+3	5 + 3 EXECUTE
-	Subtraction	5-3	5 - 3 EXECUTE
*	Multiplication	5*3 (5x3)	5 * 3 EXECUTE
/	Division	5/3 (5÷3)	5 / 3 EXECUTE
$\sqrt{\ }$	Square Root	$\sqrt{5}$	$\sqrt{\ }$ 5 EXECUTE
**	Exponentiation	5**3 (5^3)	5 * * 3 EXECUTE
log	Common Logarithm	log 5	L O G (5) EXECUTE
ln	Natural Logarithm	ln5	L O G (5) EXECUTE
EXP	Base of Natural Log	e^5	E X P (5) EXECUTE
| |	Absolute	|-5|	A B S (5) EXECUTE
EEX	Scientific Notation	5×10^3	5 E E X 3 EXECUTE

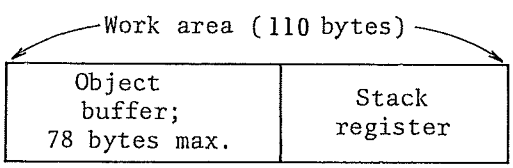
Arithmetic hierarchy is as follows :

**	exponentiation
*,/	multiplication and division
+, -	addition and subtraction

Parentheses can be used to change this hierarchy; when used, they take highest priority. However, parentheses cannot be used for implied multiplication. The * operator must always be used to indicate multiplication. Thus, executing 2(3+5) will result in error E01. The correct format is 2*(3+5).

A delta (Δ) function is also provided, but it is not intended for general keyboard calculations. It is used in defining user functions (see paragraph 3-20) or in certain keyboard calculations on the GRAPHICS, MATRIX, LIST, or SCHMOO page.

There are limits to the size of arithmetic expressions that can be executed. Refer to Figure 3-7.



The maximum allowable length of an arithmetic expression is determined by the number of bytes it contains, not by the number of characters. If an expression contains more than 78 bytes, error E03 (object buffer overflow) will appear on the CRT (below the expression) when EXECUTE is pressed. The work area for user-function arithmetic expressions, however, is 124 bytes, of which 78 bytes (max.) are used for the object buffer.

Arithmetic operators : +, -, *, /, **	1 byte
Variables and other operators	3 bytes
Constants	5 bytes

Figure 3-7. Byte Size of Arithmetic Expressions.

3-20. Up to two user functions can be defined as arithmetic expressions in the USER FCTN field on the CHANNEL DEFINITION page. This allows automatic calculation of secondary parameters, such as h_{FE} and gm, which are functions of applied and measured voltages and currents. For example, if the static collector characteristics of a bipolar transistor are to be measured and plotted, the transistor's forward current transfer ratio, h_{FE}, can be defined as HFE=IC/IB in the USER FUNCTION field on the CHANNEL DEFINITION page. HFE will appear as a softkey prompt on the MEAS&DISP MODE SETUP page and can be selected as the Y2 axis. When measurement is made on the GRAPHICS page, HFE will be plotted along with the primary characteristics—IC, IB, and VCE. Similarly, the transconductance, gm, of a field-effect transistor can be defined as GM=ΔID/ΔVG.

The delta (Δ) function can be used in user-function definitions or for keyboard calculations on the GRAPHICS, LIST, MATRIX, or SCHMOO page. In the latter case the value returned by executing ΔA (where A is the name of one of the source or monitor channels) depends on the location of the marker (GRAPHICS page) or cursor (MATRIX, LIST, and SCHMOO pages). Here, ΔA is calculated as half the difference between the values of A above and below the cursor (marker) location. In equation form

$$\Delta A = \frac{A_1 - A_2}{2}$$

where A_1 is the value of A at the measurement step following the cursor (marker) position and A_2 is the value of A at the measurement step preceeding the cursor (marker) position.

Note

The result of the arithmetic function may include a rounding error.

3-21. SOURCE AND MEASUREMENT CHANNELS

3-22. The 4145A is equipped with eight channels for device stimulus and measurement. Channels 1 through 4 are stimulus/measurement units (SMUs), channels 5 and 6 are voltage sources (VS1 and VS2), and channels 7 and 8 are voltage monitors (Vm1 and Vm2). Refer to Figure 3-8. By correctly combining and setting up the source and measurement channels, a wide range of semiconductor devices can be measured. The SMUs are described in paragraph 3-23; the voltage sources and voltage monitors, in paragraph 3-25.

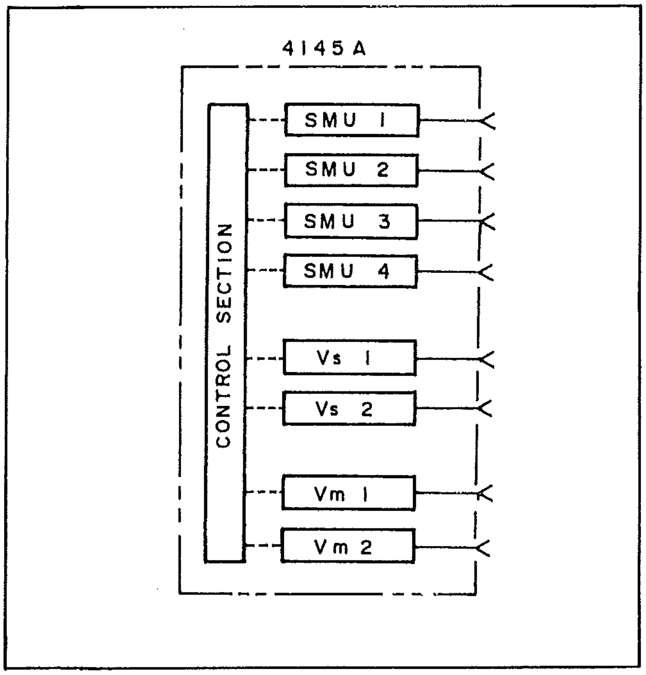


Figure 3-8. Source and Measurement Channels of the 4145A.

Note

When the current source SMU is set to 0 ampere, a slight positive current flows out.

3-23. Stimulus/Measurement Units (SMU)

3-24. A simplified circuit diagram of one of the four SMUs is illustrated in Figure 3-9. Each SMU can be set up to function as a voltage source/current monitor, current source/voltage monitor, or source common by specifying source mode V, I, or COM, respectively, in the SOURCE MODE field on the CHANNEL DEFINITION page (see Figure 3-21). Output voltage (SOURCE MODE V) and output current (SOURCE MODE I) can be held constant or can be swept (linearly or logarithmically) by specifying source function CONST or VAR1, VAR1', VAR2, respectively, in the SOURCE FCTN field on the CHANNEL DEFINITION page. When the source mode is COM, source function is automatically set to CONST. Refer to paragraph 3-29 for details on swept measurements.

Output in either SOURCE MODE is internally limited to 2 watts on each output range. Refer to Table 3-6 for range limits, range resolution, and output limits. Also, refer to paragraph 3-131 for measurement ranges and resolution. Figure 3-10 graphically illustrates the specifiable voltage/current out-put. Voltages and currents enclosed by the bold line can be specified.

Output voltage and current, sweep mode (linear or log), START, STOP, STEP, and COMPLIANCE for each SMU are specified on the SOURCE SETUP page (see Figure 3-22).

Notes:
1) Range change is performed automatically.
2) If the Current Source can't output specified current, output voltage increases up to its voltage compliance.
3) If a voltage exceeding 100V is applied to the SMU, 199.99V may be displayed as the measurement result.

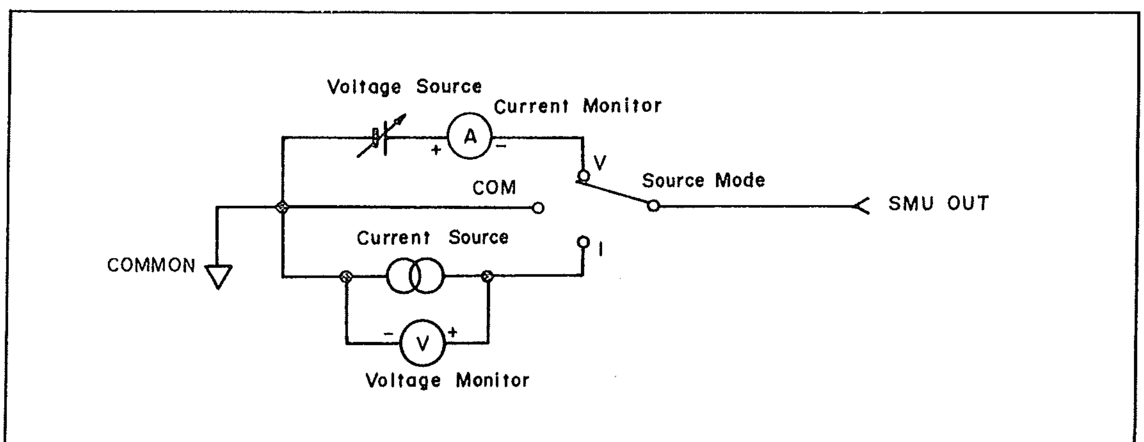
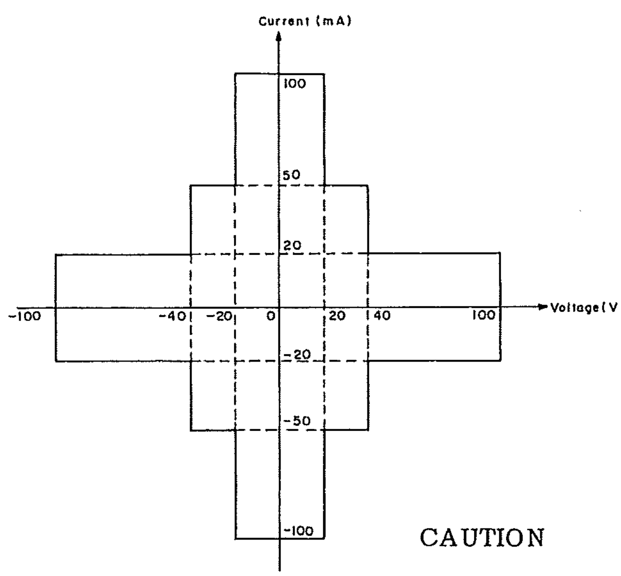


Figure 3-9. Simplified Circuit Diagram of One of the Four SMUs.

Table 3-6. SMU Source Ranges

Source Mode	Range		Resolution	Maximum Output
V	±20V		1mV	100mA
	±40V		2mV	50mA
	±100V		5mV	20mA
I	±1nA		1pA	100V
	±10nA		10pA	
	±100nA		100pA	
	±1μA		1nA	
	±10μA		10nA	
	±100μA		100nA	
	±1mA		1μA	
	±10mA		10μA	
	±100mA*	20mA	100μA	
		50mA		40V
		100mA		20V

*: The 100mA range consists of three subranges.



CAUTION

NEVER APPLY VOLTAGE OR CURRENT EXCEEDING LIMITS SHOWN IN THIS FIGURE.

Figure 3-10. Specifiable Voltage/Current Output.

3-25. Voltage Sources (Vs) and Voltage Monitors (Vm)

3-26. Simplified circuit diagrams of the voltage sources (Vs) and the voltage monitors (Vm) are shown in Figures 3-11 and 3-12, respectively. Output voltage from each Vs can be held constant or can be swept (linearly or logarithmically) by specifying source function CONST or VAR1, VAR1', VAR2, respectively, in the SOURCE FUNCTION field on the CHANNEL DEFINITION page (see Figure 3-21). Refer to paragraph 3-29 for details on swept measurements. Maximum output voltage is ±20V with 1mV resolution. Maximum output current is 10mA.

Up to ±20V can be measured by the voltage monitors. There are two measurement ranges : 20V and 2V. Resolution for each range is 1mV and 100μV, respectively.

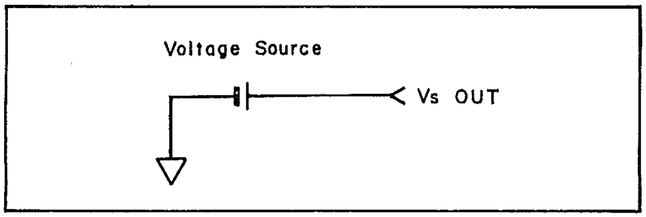


Figure 3-11. Simplified Circuit Diagram of Vs.

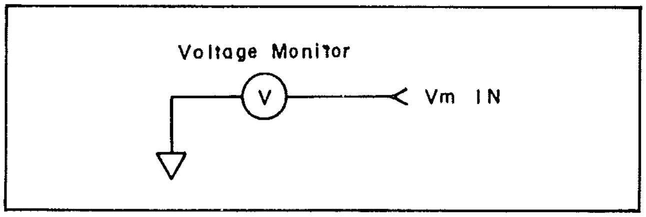


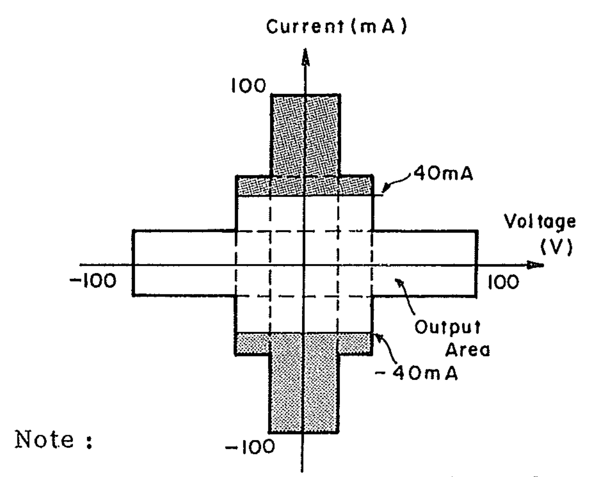
Figure 3-12. Simplified Circuit Diagram of Vm.

3-27. COMPLIANCE

3-28. To prevent over-voltage or over-current damage to the device under test, several levels of output protection, termed COMPLIANCE, have been incorporated into the 4145A. The maximum output current from an SMU operating in SOURCE MODE V (voltage source/current monitor) can be specified by entering the desired limit in the COMPLIANCE field of each source channel on the SOURCE SETUP page. Similarly, the maximum output voltage from an SMU operating in SOURCE MODE I (current source/voltage monitor) can be specified. Maximum specifiable compliance depends on the voltage or current range at which the source channel is operating. Refer to the Maximum Output column in Table 3-6. Setting resolution for current and voltage compliance is 50pA and 1mV, respectively. When an SMU is operating in SOURCE MODE COM, its current compliance is automatically set to 105mA and cannot be changed.

If a source channel reaches compliance during measurement, an error code (see Table 3-3) will appear on the CRT. Measurement data obtained prior to this point is valid, but measurement data obtained after compliance is reached may not be valid. The reason for this is that once a source channel reaches compliance, it tends to act as a constant source. Consider, for example, an SMU that is set to SOURCE MODE V (voltage source/current monitor) and SOURCE FCTN VAR1 (variable voltage source). START voltage, STOP voltage, and COMPLIANCE are 0V, +20V, and 10mA, respectively. Also, assume that the device under test has a resistance of 1000 ohms. When the measurement is started, the SMU will be begin sweeping its output voltage toward +20V. But when the output voltage reaches +10V, the current through the device under test is 10mA. Compliance has been reached. The SMU will continue to try to sweep toward the +20V STOP voltage, but because the current through the device under test is now constant at 10mA, the voltage across it must be constant at +10V.

The specified compliance is valid for positive and negative values, regardless of the polarity specified in the COMPLIANCE field; that is, specifying a current compliance of, say, 40mA, as in Figure 3-13, is valid for +40mA and -40mA. Output currents greater than ±40mA (shaded areas in Figure 3-13) are not possible.



Note :

Do not set the SMU's voltage compliance too high (I mode) or the current compliance too low (V mode).

Figure 3-13. Voltage/Current Output Specified by the COMPLIANCE.

3-29. SWEEP MEASUREMENT

3-30. Output from the SMUs and voltage sources (Vs) can be swept in a staircase manner, as shown in Figure 3-14, by specifying VAR1, VAR1', or VAR2 in the SOURCE FCTN field on the CHANNEL DEFINITION page. The maximum number of source channels that can be swept is three. VAR1, VAR1', and VAR2 can be specified only once on the CHANNEL DEFINITION page and VAR1' cannot be specified without VAR1. VAR1, VAR1', and VAR2 are described in paragraph 3-31.

Sweep setup is made on the SOURCE SETUP page by selecting the SWEEP MODE and entering the desired START, STOP, STEP, DELAY, and HOLD values. Each sweep parameter is described below :

START : Voltage or current value at which sweep begins

STOP : Voltage or current value at which sweep stops

STEP : Sweep incremental or decremental value. Can be specified in LINEAR SWEEP MODE only.

DELAY : Wait time before measurement is made at each step (softkey function).

HOLD : Wait time before sweep begins (softkey function).

SWEEP MODE :
LINEAR or LOG. In LINEAR mode, output is swept linearly in accordance with the specified STEP value. In LOG mode, output is swept logarithmically at 10 steps, 25 steps or 50 steps (selectable with softkeys) per decade. LOG cannot be specified for VAR2. Refer to paragraph 3-32 for further details on LOG sweeps.

The above sweep parameters are for VAR1 only. Sweep parameters available for VAR2 are START, STEP, and NO. OF STEPS. Sweep parameters available for VAR1' are OFFSET (specifiable in linear sweep mode only) and RATIO, both of which are softkey functions. Also, when displaying measurement results on the GRAPHICS page, either LINEAR or LOG scaling can be specified on the MEAS/DISP MODE SETUP page, regardless of the SWEEP MODE of VAR1.

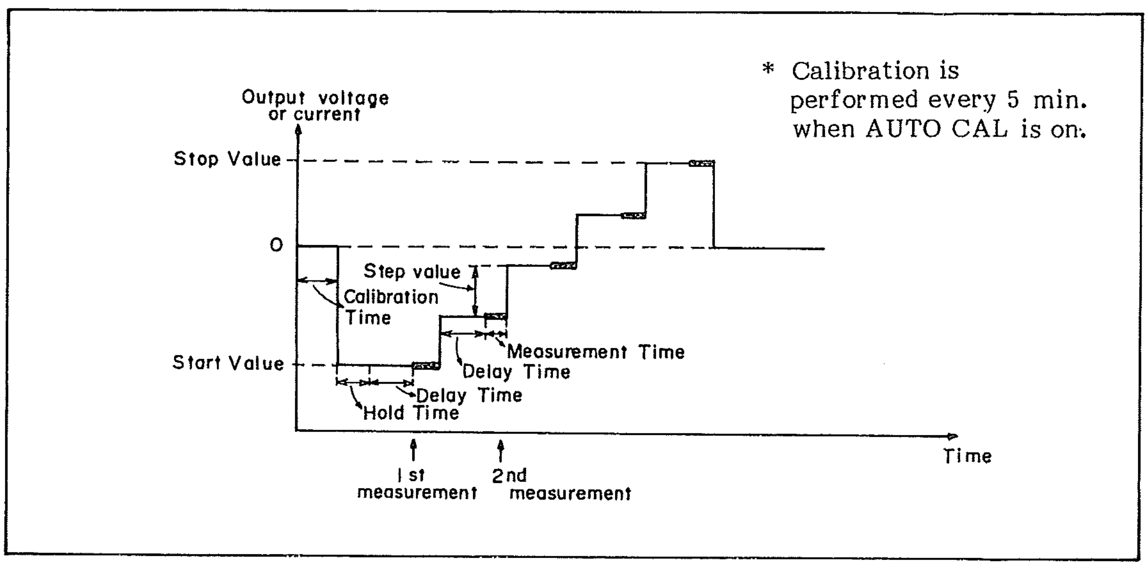


Figure 3-14. Staircase Sweep Output.

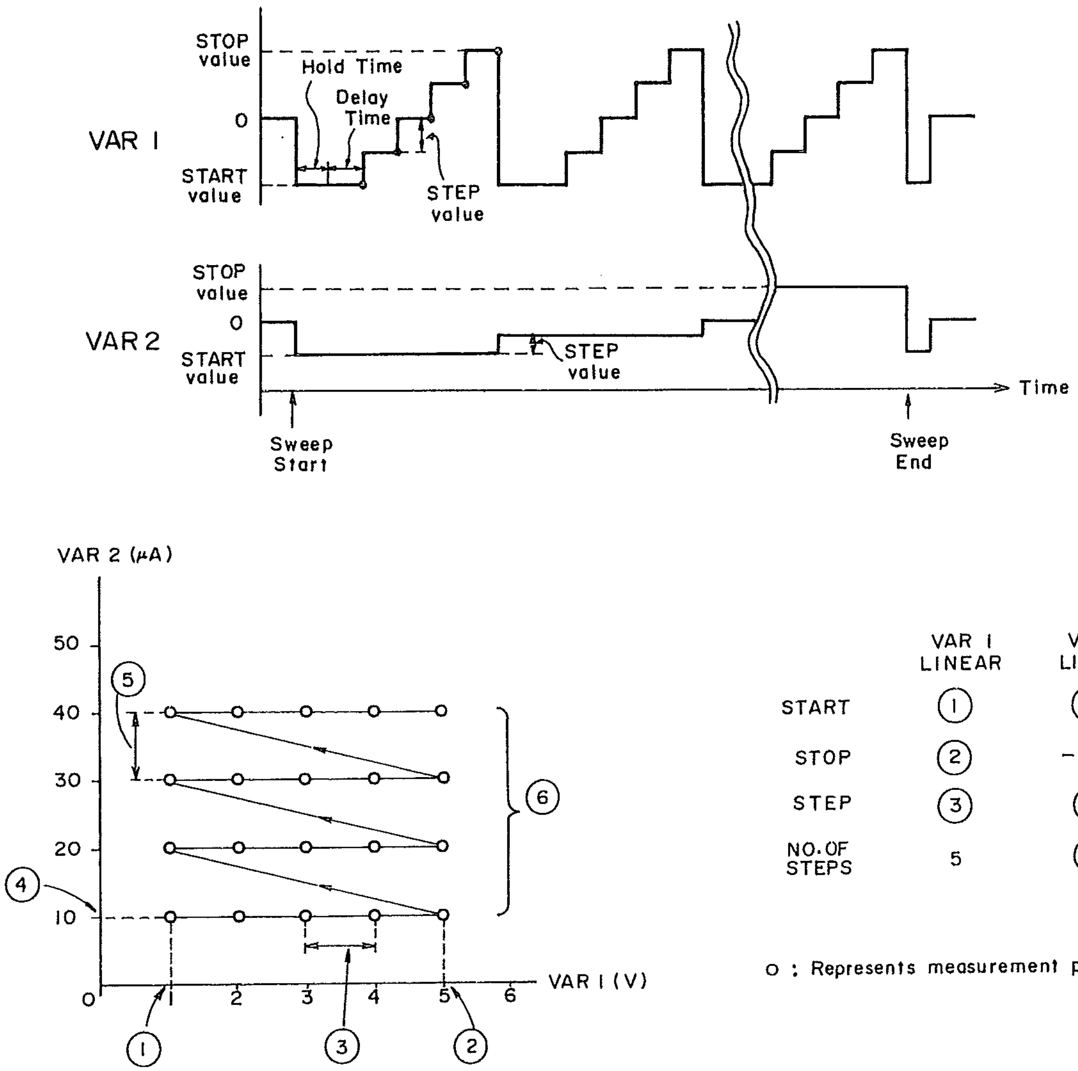
3-31. Of the six source channels (four SMUs, two voltage sources), three can be swept by specifying VAR1, VAR1', or VAR2 in the SOURCE FCTN field on the CHANNEL DEFINITION page. The remaining three source channels are either "not used" or are set to CONST source function. The VAR1 source channel is the main sweep channel and VAR2 and VAR1' are VAR1 dependent, as shown in Figures 3-15 and 3-16, respectively, and as described below:

VAR2 (subordinate sweep):

At the completion of the VAR1 sweep, VAR2 is incremented or decremented by the specified STEP value (5 in Figure 3-15) and VAR1 is swept again. The total number of VAR1 sweeps is determined by the NO. OF STEPS (6 in Figure 3-15) specified for VAR2. VAR2 cannot be swept logarithmically. Also, VAR1 and VAR2 can have different source functions. START, STEP, and NO. OF STEPS must be specified.

VAR1' (synchronous sweep):

VAR1' can be used only when VAR1 is used and it must have the same source mode (V or I) as that specified for VAR1. VAR1' is swept in synchronism with VAR1 at either a constant offset value or constant ratio. VAR1' offset and ratio values are entered with the corresponding softkey. The offset value and ratio must be such that the VAR1' source channel does not exceed its maximum output limits.



	VAR 1 LINEAR	VAR 2 LINEAR
START	1	4
STOP	2	---
STEP	3	5
NO. OF STEPS	5	6

o : Represents measurement pointo

Figure 3-15. Relationship Between VAR1 and VAR2.

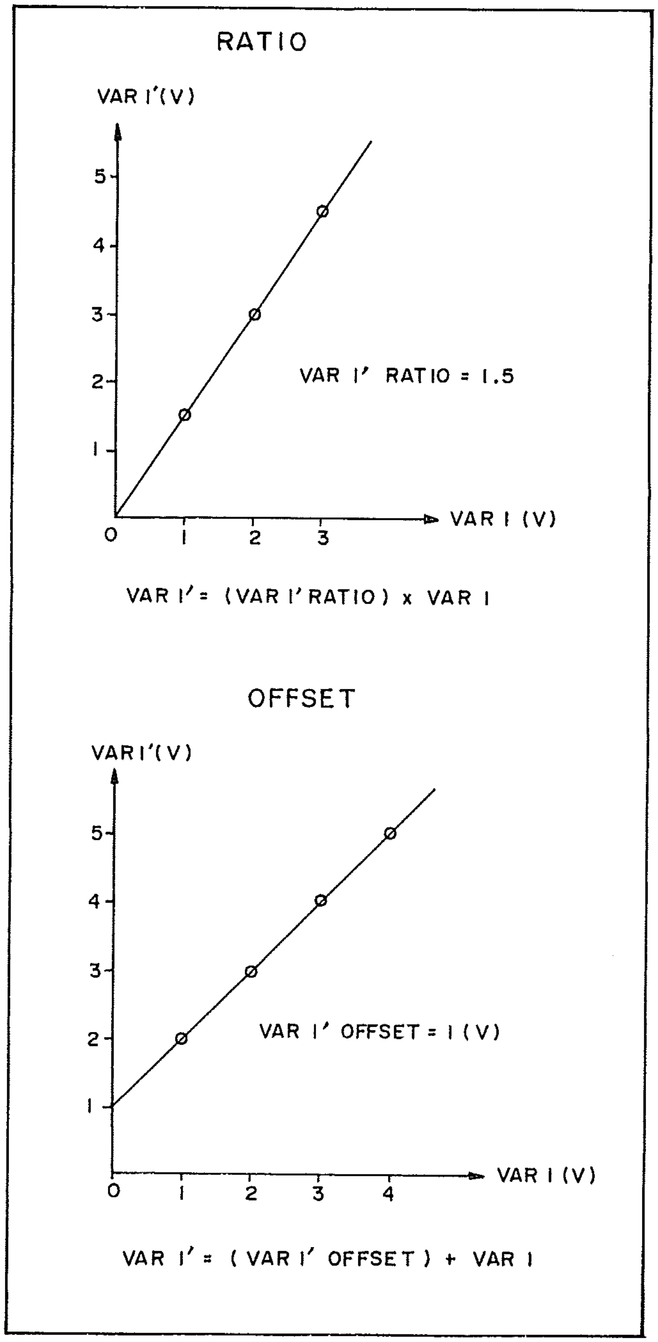


Figure 3-16. Relationship Between VAR1 and VAR1'.

3-32. The number of measurement points per decade in LOG sweep is selectable at 10, 25, or 50. The output at each point is determined by the number of measurement points per decade and the sweep START value. The output at the nth measurement point is calculated as :

$$\text{Output at nth point=START value} \times 10^{\frac{n-1}{\alpha}} \quad (3\text{-}1)$$

where α is the number of measurement points per decade (10, 25, 50).

3-33. TIME DOMAIN MEASUREMENT

3-34. A time domain measurement is one in which the voltages and/or currents applied to the device under test are held constant and the desired device parameter is measured as a function of time. Only one source channel can be swept and only with the VAR2 source function. All other channels are either "not used" or must be set to CONST source function. Selectable TIME DOMAIN parameters are WAIT TIME, INTERVAL, and NO. OF RDNGS (number of readings). Each is described below :

WAIT TIME:
: Time before source channels begin outputting voltage or current. Also valid for the VAR2 source channel. Setting range is from 0 to 100 seconds and resolution is 10 milliseconds.

INTERVAL:
: Time between each measurement point. Setting range is from 10 milliseconds to 10 seconds and resolution is 10 milliseconds.

NO. OF RDNGS:
: Total number of measurement points. If VAR2 is used, NO. OF RDNGS per each step of VAR2. Up to 512 measurement points can be specified, depending on the number of VAR2 steps.

To make a TIME DOMAIN measurement, do not assign VAR1 to any of the source channels on the CHANNEL DEFINITION page. (Assigning VAR2 is optional.) Output values for all CONST sources must still be entered on the SOURCE SETUP page. If VAR2 is used, its START, STEP, and NO. OF STEPS must also be entered. Also, HOLD TIME and DELAY TIME are not used in a TIME DOMAIN measure- ment.

TIME DOMAIN parameters—WAIT TIME, INTERVAL, and NO. OF RDNGS—must be entered on the MEAS/DISP MODE SETUP page. Refer to Figure 3-33. Integration time during TIME DOMAIN measurement is automatically set to SHORT and cannot be changed.

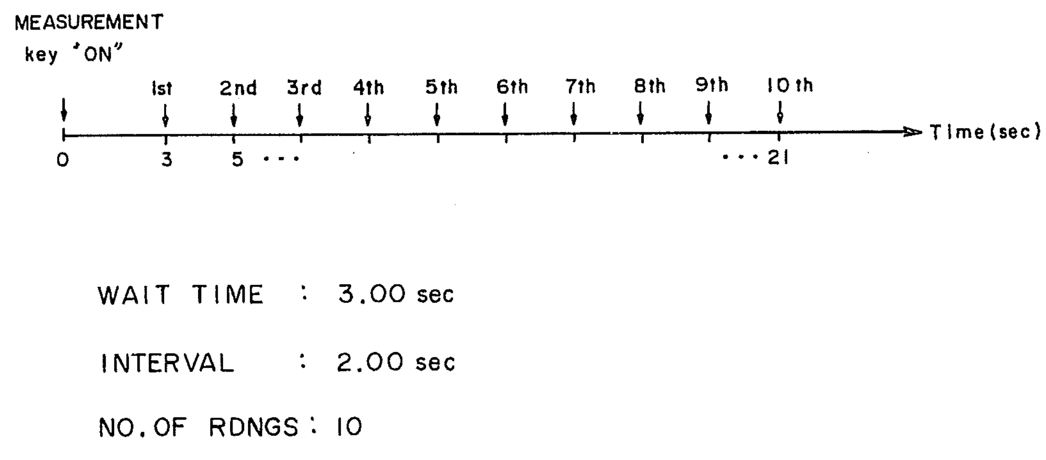


Figure 3-17. Time Domain Measurement.

3-35. INTEGRATION TIME

3-36. To prevent line frequency noise and other noise sources from affecting the accuracy of measurements, the 4145A is equipped with three digital integration times, which are selectable from the front panel. Each is described below :

SHORT : Digital integration is not performed.

MEDIUM : Measurement result is the average value of 16 samples taken during one line frequency period.

LONG : Measurement result is the average value of 256 samples taken during sixteen line frequency periods.

Integration time can be changed during measurement, but cannot be changed while the 4145A is in TALK mode (PLOT or PRINT), when the disc drive's read/write lamp first comes on, or during auto scaling. In time domain measurements only SHORT integration time is available.

3-37. AUTO-CALIBRATION

3-38. To both monitor and compensate for transient changes in output voltage and current caused by ambient temperature changes, each SMU is equipped with an auto-calibration function. This function allows each SMU to periodically monitor its own output and, if necessary, provide appropriate compensation.

3-39. The auto-calibration function of the SMUs is controlled by the AUTO CAL key on the front panel. With AUTO CAL turned on (key indicator lamp on), calibration is automatically performed every five minutes for about six seconds. If one of the MEASUREMENT keys or the AUTO CAL key is pressed during auto-calibration, "Busy" will be displayed on the CRT until auto-calibration is completed.

3-40. DISPLAY PAGES

3-41. The 4145A displays thirteen different screens. Each screen is called a page and each has a different purpose in relation to instrument operation. By changing from one page to another, different functions and capabilities, such as measurement set up, measurement, diagnostics, certain filing functions, etc., are made available. PAGE control is described in paragraph 3-42. Detailed explanations of each page are given Figures 3-20 through 3-32.

3-42. PAGE CONTROL

3-43. Display paging is controlled by the PAGE CONTROL keys—MENU, NEXT, and PREV—or the softkeys, as shown in Figure 3-18. (Softkeys for PAGE control are available only when the MENU is displayed.) Page-flow and the relationship between pages are shown in Figure 3-19. The solid lines (——→) show page changes that are possible with the NEXT key or PREV key; the dashed lines (---→) show page changes that are possible with the softkeys. To go to the GRAPHICS, LIST, MATRIX, or SCHMOO page from the MEAS/DISP MODE SETUP page, it is first necessary to select the desired display mode with the softkeys and then press the NEXT key.

All pages except the GRAPHICS, LIST, MATRIX, and SCHMOO pages can be displayed directly from the MENU page by pressing the appropriate softkey. For example, pressing softkey 3 while the MENU page is displayed automatically displays the MEAS/DISP MODE SETUP page. Pressing the MENU key automatically returns the display to the MENU page, regardless of the present display page. To change from the GRAPHICS page to, say, the LIST page, press the PREV key to display the MEAS/DISP MODE SETUP page, select LIST with the softkeys, and then press the NEXT key. Paging cannot be performed during measurement, printing, or plotting.

3-44. When the NEXT key or PREV key is pressed while the CHANNEL DEFINITION page, SOURCE SETUP page, MEAS/DISP MODE SETUP, or OUTPUT SEQUENCE SETUP page is displayed, the page is checked for completeness and correctness. If an illegal setup is detected, an error message will be displayed and no page change will occur. In this case you must either correct the setup or press the MENU key. Changes made on the CHANNEL DEFINITION, SOURCE SETUP, MEAS/DISP MODE SETUP and OUTPUT SEQUENCE SETUP pages are not valid for SAVE until the PREV or NEXT key is pressed.

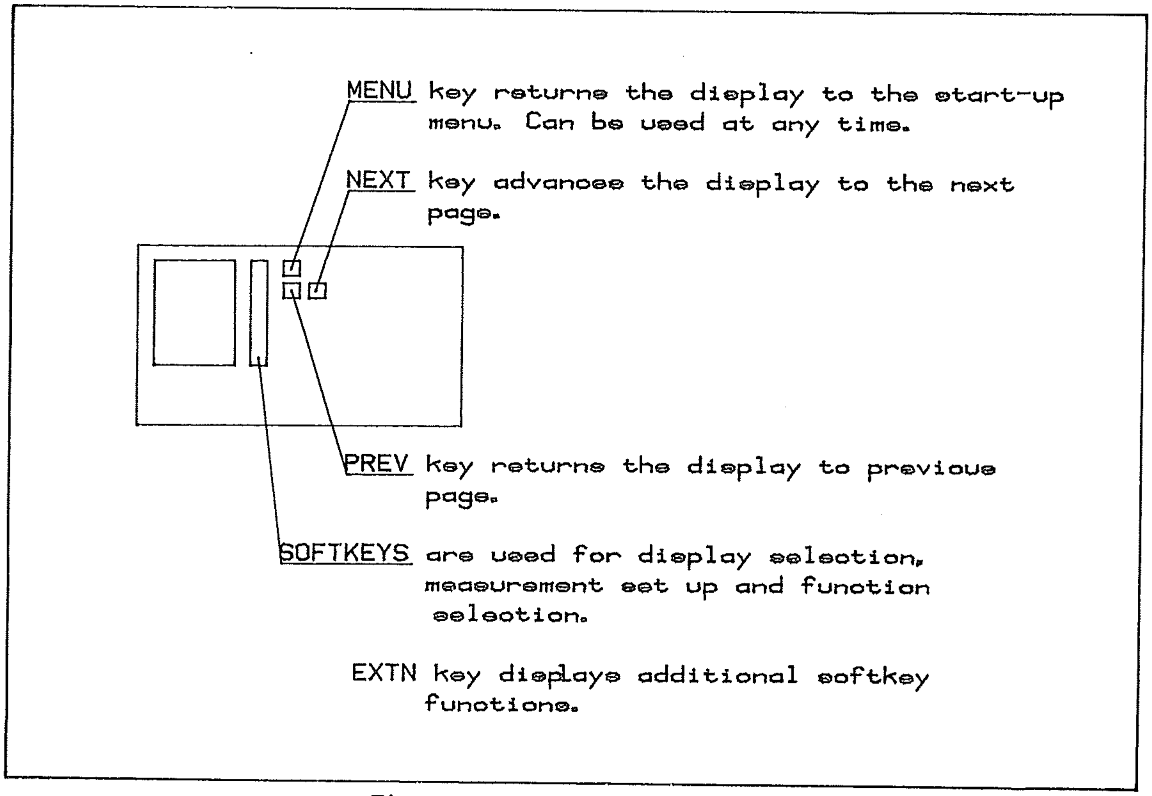
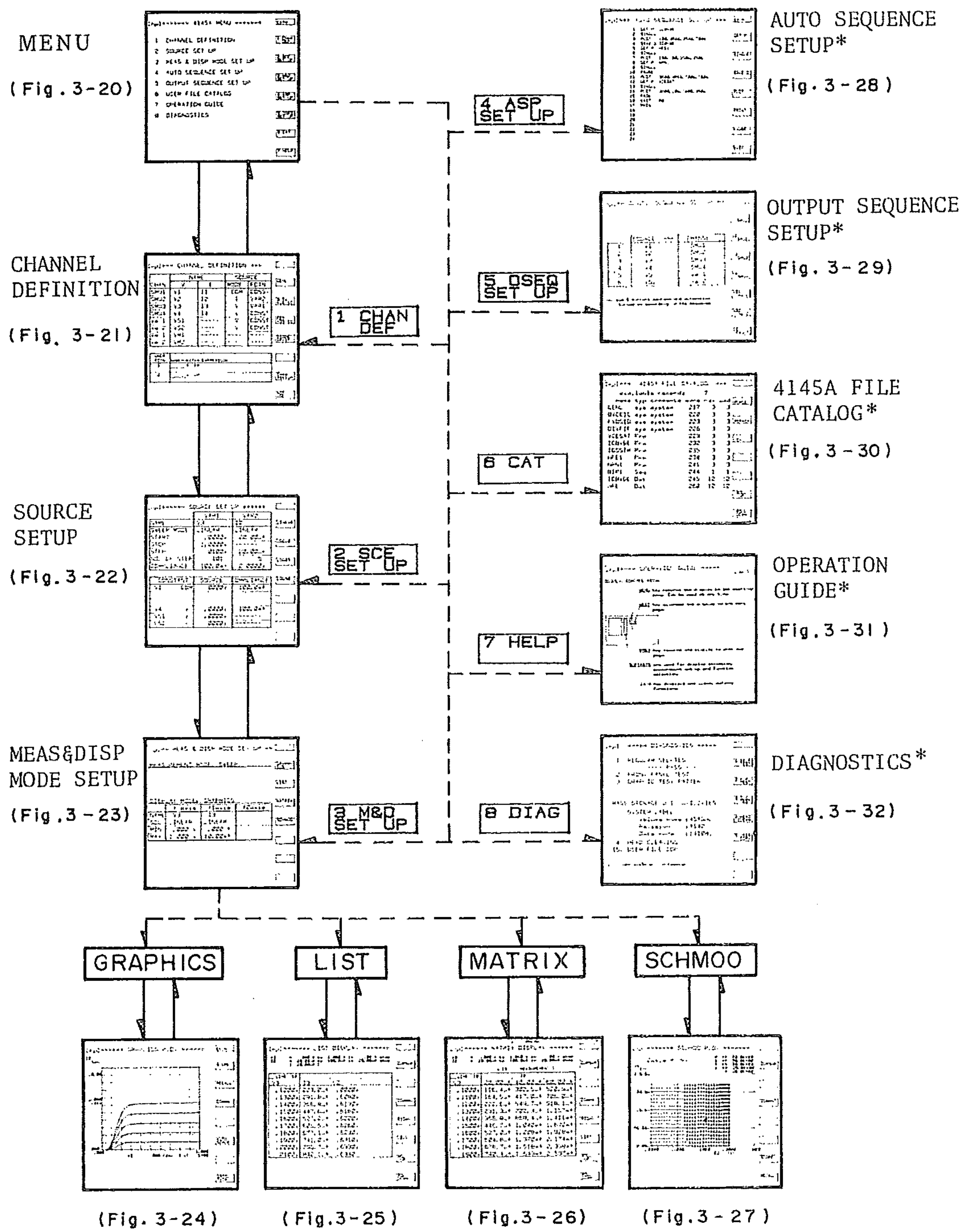


Figure 3-18. Page Control Keys.



* If the PREV key is pressed on these pages, display returns to the MENU page.

** MENU key can be used to return to the MENU page at any time.

Figure 3-19. Page Flow and the Relationship.

3-45. MENU PAGE

3-46. The start-up menu is displayed when the instrument is turned on and each time the MENU key is pressed. Displayed on the MENU page are the accessible pages, corresponding softkey prompts (SKP), the instrument's present HP-IB status, line frequency filter setting, and the status of each SMU. A detailed description of the MENU page is given in Figure 3-20.

3-47. CHANNEL DEFINITION PAGE

3-48. The CHANNEL DEFINITION page is displayed when softkey 1 or the NEXT key is pressed while the MENU page is displayed. On this page the operator must define the name, mode, and function of each channel that is to be used in the measurement. User functions are also defined on this page. A detailed description of the CHANNEL DEFINITION page is given in Figure 3-21.

3-49. SOURCE SETUP PAGE

3-50. The SOURCE SETUP page is displayed when softkey 2 is pressed on the MENU page or when the NEXT key is pressed on the CHANNEL DEFINITION page. On this page the operator must enter the output parameters (START, STOP, STEP, COMPLIANCE, etc.) for the source channels (SMUs and voltage sources) defined on the CHANNEL DEFINITION page. A detailed description of the SOURCE SETUP page is given in Figure 3-22.

3-51. MEAS/DISP MODE SETUP PAGE

3-52. The MEAS/DISP MODE SETUP page is displayed when softkey 3 is pressed on the MENU page or when the NEXT key is pressed on the SOURCE SETUP page. On this page the operator must select the desired display mode (GRAPHICS, LIST, MATRIX, SCHMOO), enter the appropriate source and monitor names, and enter the desired scaling factors. A detailed description of the MEAS/DISP MODE SETUP page is given in Figure 3-23.

3-53. GRAPHICS PLOT PAGE

3-54. The GRAPHICS PLOT page is displayed when the MEAS/DISP MODE SETUP page has been set up for GRAPHICS MODE DISPLAY and the NEXT key is pressed. On this page the operator can make the measurement by pressing the SINGLE, REPEAT, or APPEND key and can analyze the measurement results with the softkeys. A detailed description of the GRAPHICS PLOT page is given in Figure 3-24.

3-55. LIST DISPLAY PAGE

3-56. The LIST DISPLAY page is displayed when the MEAS/DISP MODE SETUP page has been set up for LIST mode display and the NEXT key is pressed. On this page the operator can make the measurement by pressing the SINGLE, REPEAT, or APPEND key and can analyze the measurement results with the softkeys. A detailed description of the LIST DISPLAY page is given in Figure 3-25.

3-57. MATRIX DISPLAY PAGE

3-58. The MATRIX DISPLAY page is displayed when the MEAS/DISP MODE SETUP page has been set up for MATRIX mode display and the NEXT key is pressed. On this page the operator can make the measurement by pressing the SINGLE, REPEAT, or APPEND key and can analyze the measurement results with the softkeys. A detailed description of the MATRIX DISPLAY page is given in Figure 3-26.

3-59. SCHMOO PLOT PAGE

3-60. The SCHMOO PLOT page is displayed when the MEAS/DISP MODE SETUP page has been set up for SCHMOO mode display and the NEXT key is pressed. On this page the operator can make the measurement by pressing the SINGLE or REPEAT key and can analyze measurement results with the softkeys. A detailed description of the SCHMOO PLOT page is given in Figure 3-27.

3-61. AUTO SEQUENCE SETUP PAGE

3-62. The AUTO SEQUENCE SETUP page is displayed when softkey 4 is pressed on the MENU page. On this page the operator can set up an auto-sequence program (ASP). A detailed description of the AUTO SEQUENCE SETUP page is given in Figure 3-28.

3-63. OUTPUT SEQUENCE SETUP PAGE

3-64. The OUTPUT SEQUENCE SETUP page is displayed when softkey 5 is pressed on the MENU page. On this page the operator can specify the order in which the SMUs and voltage sources begin output. A detailed description of the OUTPUT SEQUENCE SETUP page is given in Figure 3-29.

3-65. USER FILE CATALOG PAGE

3-66. The USER FILE CATALOG page is displayed when softkey 6 is pressed on the MENU page. On this page the operator can PURGE or REPACK files stored on the flexible disc. The number of records available, stored files, file type, comments, file addresses, number of records reserved for each file, and number of records actually used by each file are displayed. A detailed description of the USER FILE CATALOG page is given in Figure 3-30.

3-67. OPERATION GUIDE PAGE

3-68. The OPERATION GUIDE page is displayed when softkey 7 is pressed on the MENU page. This page provides brief paging information and brief descriptions of error messages and error codes. A detailed description of the OPERATION GUIDE page is given in Figure 3-31.

3-69. DIAGNOSTICS PAGE

3-70. The DIAGNOSTICS page is displayed when softkey 8 (press EXTN softkey to display softkey 8) is pressed on the MENU page. On this page the operator can perform SELF TEST, front panel test, graphics display test, disc cleaning, and disc copy (user-area only). A detailed description of the DIAGNOSTICS page is given in Figure 3-32.

3-71. SOFTKEY PROMPTS (SKP)

3-72. Softkey prompts (the function of each softkey) are displayed along the right side of the CRT display. There are eight softkeys, and the softkey prompts for the lower seven keys change depending on the page being displayed and the position of the Field Pointer (▶) on the CHANNEL DEFINITION, SOURCE SETUP, and MEAS/DISP MODE SETUP pages. The softkey prompt of the top softkey is always EXTN (extended), regardless of the page being displayed or the position of the Field Pointer. EXTN is displayed only when additional softkey functions exist.

3-73. SYSTEM MESSAGES

3-74. System messages are instructions to the operator and are displayed on the System Message Line (refer to Figure 3-5), which is located at the bottom of the CRT display. System messages guide the operator through all phases of instrument operation, and make measurement setup a simple matter of filing in blanks on the CHANNEL DEFINITION, SOURCE SETUP, and MEAS/DISP MODE SETUP pages.

MENU PAGE

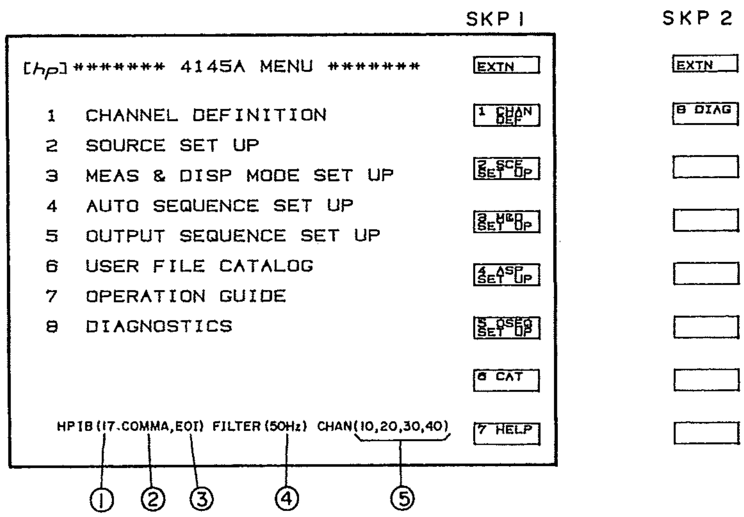


Figure A

Initial Condition :

When the 4145A is turned on, the display will be blank while SELF TEST is being performed. When SELF TEST has been completed and no fatal error have been detected, the MENU page will be displayed as shown in Figure A. The status of the instrument, as detected by the SELF TEST, is displayed at the bottom of the CRT.

1 : HP-IB Address (0 - 30) :
Shows the setting of the HP-IB Control Switch (located on the rear panel). To change the address, turn the instrument off, set the desired address, and turn the instrument on again.

2 : Output data delimiter :
COMMA or CR/LF is displayed depending on the setting of the HP-IB Control Switch.

3 : EOI (End or Identify) :
EOI is displayed when bit 7 of the HP-IB Control Switch is set to EOI ON.

4 : Line Filter setting :
Indicates the setting of the Line Filter Switch on the rear panel. (50Hz) indicates that the instrument is set for operation from a 50Hz AC source. The LINE FILTER switch on the rear panel should be set to the frequency of the AC source if accurate measurements are to be obtained.

Figure 3-20. MENU Page (Sheet 1 of 2).

5 : SMU Status :
Displays each SMU channel number and its status. (10, 20, 30, 40) indicates that all SMUs are functioning properly. Each 2-digit number represents the channel number and the channel status.

XX
- Error Code
- Channel No.

0 :	No error
1 :	V offset error
2 :	I offset error
3 :	I leak
4 :	V range error
5 :	I range error
6 :	Iin offset error
7 :	Loop Change Detector error

For example, (10, 20, 31, 40) indicates that SMU 3 has a V offset error and should not be used. SMUs 1, 2, and 4, however, are functioning properly and can be used for measurement. When (!!!DOWN!!!) is displayed, the SMU control circuit is not functioning properly and, thus, measurement can not be made.

Softkey Prompts (SKP) :

The MENU page has two softkey prompts (SKP1 and SKP2), as shown in Figure A. SKP1 is displayed when the MENU page first appears. To display SKP2, press the EXTN softkey; to re-display SKP1, press the EXTN softkey again.

Note

If the instrument is turned on after experiencing an extreme change of ambient temperature, one of error code may be displayed. In this case, allow the instrument to fully warm up (ignor the displayed error code), and then turn it off and on one time.

Figure 3-20. MENU Page (Sheet 2 of 2).

CHANNEL DEFINITION PAGE

SKP 3

[hp] *** CHANNEL DEFINITION ***

	NAME		SOURCE	
CHAN	V	I	MODE	FCTN
SMU1	V1	I1	COM	CONST
SMU2	V2	I2	I	VAR2
SMU3	V3	I3	V	VAR1
SMU4	V4	I4	V	CONST
Vs 1	VS1	-----	V	CONST
Vs 2	VS2	-----	V	CONST
Vm 1	VM1	-----	-----	-----
Vm 2	VM2	-----	-----	-----

USER FCTN	NAME (UNIT) = EXPRESSION
1	____ ( )=
2	____ ( )=

GENL
B-T VCE-IC
FET VDS-ID
DIODE VF-IF
CHAN ASSIGN
NOT USE

Figure A

Purpose and function of this Page :

1. To assign voltage (V) and current (I) names to each channel that will be used in the measurement.

2. To set the source mode of each SMU. (Determines whether the SMU will be used as a V source or I source.)

3. To set the source function of each SMU. (Determines whether the SMU will be used as a constant source or variable source.)

4. To define User Functions.

Initial Condition :

When the 4145A is turned on, the CHANNEL DEFINITION page is automatically setup as shown in Figure A and the field-pointer (▶) will be located in the V column of SMU1. (This setup is the GENL measurement setup stored on each disc. Refer to paragraph 3-87.)

Field-Pointer (▶) :

Changing or entering a V NAME, I NAME, SOURCE MODE, SOURCE FUNCTION, or USER FUNCTION can be accomplished only by positioning the field-pointer at the field to be changed. New information can then be entered with the appropriate front panel keys or softkeys. Positioning of the field-pointer is controlled by the CURSOR keys (FAST cannot be used on this page). When one of these keys is pressed the field-pointer will move one field in the direction of the arrow labelled on the key. Also, each time new information is entered into a field, the field-pointer will automatically move to the next field, as shown in Figure B.

Figure 3-21. CHANNEL DEFINITION Page (Sheet 1 of 4).

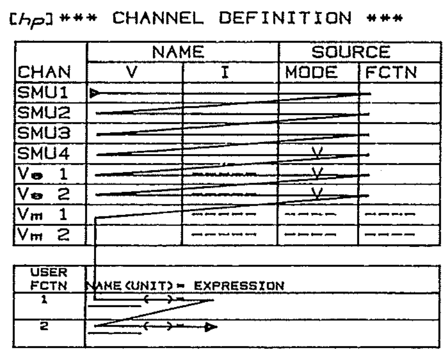


Figure B

NAME and USER FUNCTION Entry:

(1) Position the field-pointer at the desired field.

(2) Key in the desired name or user-function expression (it will appear on the Keyboard Input Line on the CRT as you do so).

(3) Press ENTER. The name or expression will be moved from the Keyboard Input Line to the field at which the field-pointer is positioned and the field-pointer will move to the next field.

Note

V NAME, I NAME, and USER FCTN NAME can be up to six characters long, of which the first character must be alphabetic and the remaining characters must be alphanumeric. A NAME can be used only once on this page. USER FCTN expressions can be up to sixty characters long and can contain channel names (V or I), numerics, and arithmetic operators.

SOURCE MODE and SOURCE FCTN Entry:

(1) Position the field-pointer at the desired field.

(2) Select the desired mode or function from those listed on the softkey prompts. (The softkey prompts will change depending on the location of the field-pointer.)

(3) When the softkey is pressed, the selected mode or function will appear in the field and the field-pointer will move to the next field.

Note

SOURCE MODE and SOURCE FCTN can be entered only with the softkeys.

Figure 3-21. CHANNEL DEFINITION Page (Sheet 2 of 4).

V NAME and I NAME :

These are unique names used to identify each channel that is to be used in the measurement. Each SMU has two names : one for its source function and one for its monitor function. Both must be entered if the SMU has been assigned a SOURCE MODE. If no V NAME is entered for a voltage source (Vs) or voltage monitor (Vm), the channel is considered as not used. The NOT USE softkey can be used to delete the NAMEs, SOURCE MODE, and SOURCE FCTN of a channel and effectively turn it off. The NOT USE softkey is available only when the field-pointer is in the V NAME column.

SOURCE MODE :

Each SMU used in the measurement must be assigned a SOURCE MODE. Three SOURCE MODEs are available : V (voltage source/current monitor), I (current source/voltage monitor), and COM (common). A COM source is regarded as a voltage source whose output is 0V and compliance is 105mA. SOURCE MODE selection can be made only with the softkeys and only when the field-pointer is in the SOURCE MODE column.

SOURCE FCTN :

Each SMU and each Vs used in the measurement must be assigned a SOURCE FCTN. Four SOURCE FCTNs are available : VAR1 (main sweep), VAR1' (synchronous sweep), VAR2 (subordinate sweep), and CONST (constant source). SOURCE FCTN selection can be made only with the softkeys and only when the field-pointer is in the SOURCE FCTN column. Refer to paragraph 3-29 for details on VAR1, VAR1', and VAR2.

Note

If the SOURCE MODE of an SMU is COM, SOURCE FCTN is automatically set to CONST.

USER FCTN :

The user function is an extremely versatile, useful analysis aid. It is a user-defined arithmetic expression consisting of variables (V NAMES and I NAMES only) and constants and is executed at each measurement point during measurement. The results can be displayed (GRAPHICS PLOT, LIST, MATRIX, SCHMOO) along with measurement results. Any of the arithmetic operators listed in Table 3-5, plus Δ and parentheses, can be used in USER FCTN expressions. The only variables that can be used in a USER FCTN expression are the names listed in the V NAME and I NAME columns on the CHANNEL DEFINITION page. Two USER FCTNs can be defined and each can be up to 60 characters long.

SOFTKEY PROMPTS and SOFTKEYS FUNCTIONS :

The softkey prompts (SKP) displayed on the CRT automatically change as the field-pointer is moved to different areas of the page. The relationship between field-pointer location and the softkey prompts is shown in Figures C and D. For example, when the field-pointer is at 4 in Figure C, SKP 6 in Figure D, will be displayed on the CRT. SKP 8 and SKP 9 are displayed only after the CHAN ASSIGN softkey has been pressed on SKP3.

Figure 3-21. CHANNEL DEFINITION Page (Sheet 3 of 4).

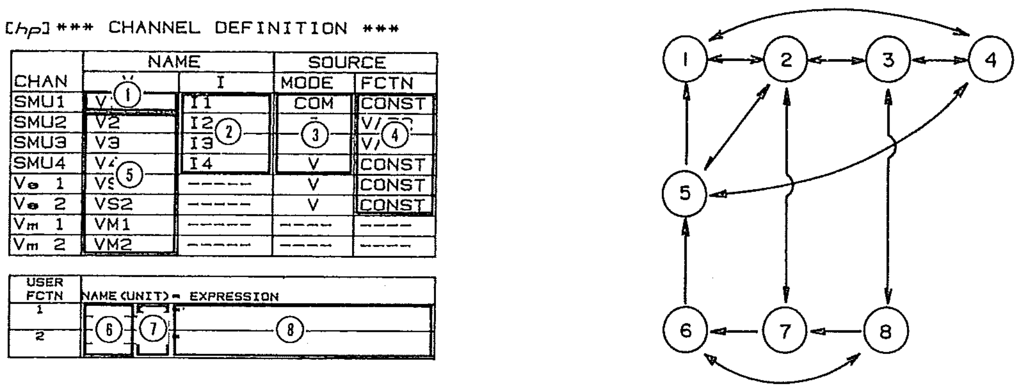


Figure C

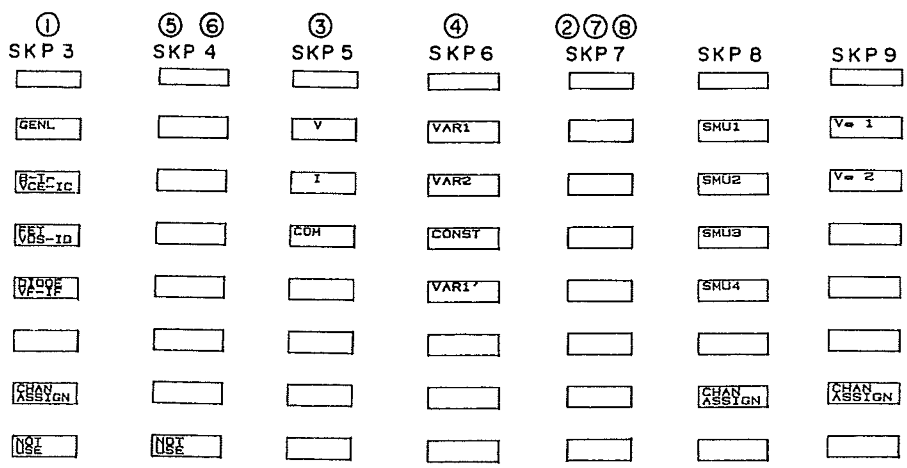


Figure D

CHAN ASSIGN (Channel Assignment):

This softkey allows you to quickly rearrange the SMU and Vs channel assignments, without having to reassign channel names (V and I), SOURCE MODEs, and SOURCE FCTNs. It is extremely helpful when DUT connections have been made or when measuring devices which require the same measurement setup but which have different pin-outs. The procedure is given below.

(1) Move the field-pointer to area (1) in Figure C. SKP 3 in Figure D, will be displayed.

(2) Press the CHAN ASSIGN softkey. The field-pointer will automatically move to the first row in the CHAN column, rows 1 through 6 in the CHAN column will be blank, and SKP8 will be displayed.

(3) Assign the channel numbers in the desired order. The field-pointer will move down the CHAN column as you do so. When the field-pointer reaches the fifth row, SKP9 will be displayed.

(4) Press the CHAN ASSIGN softkey again to enter the new channel assignments. The field-pointer will move back to area (1) in Figure C.

Figure 3-21. CHANNEL DEFINITION Page (Sheet 4 of 4).

SOURCE SETUP PAGE

SKPIO

[hp] ****** SOURCE SET UP ******

	VAR1	VAR2
NAME	V3	I2
SWEEP MODE	LINEAR	LINEAR
START	.ØØØØV	2Ø.ØØuA
STOP	1.ØØØØV	-------
STEP	.Ø1ØØV	2Ø.ØØuA
NO. OF STEP	1Ø1	5
COMPLIANCE	1ØØ.ØmA	2.ØØØØV

CONSTANT		SOURCE	COMPLIANCE
V1	COM	.ØØØØV	1ØØ.ØmA
V4	V	.ØØØØV	1ØØ.ØmA
VS1	V	.ØØØØV	--------
VS2	V	.ØØØØV	--------

LINEAR

LOG1Ø

LOG25

LOG5Ø

Figure A

Purpose and function of this page :

1. Select the sweep mode (linear or log) for the VAR1 source channel.
2. Set the START, STOP, and STEP values for the VAR1 source channel.
3. Set the START and STEP values and NO. OF STEP for the VAR2 source channel.
4. Set the RATIO and OFFSET values for the VAR1' source channel.
5. Set the HOLD TIME and DELAY TIME.
6. Set the source (output) value for the CONST channels.
7. Set the COMPLIANCE value for each source channel.

Setup :

To change or enter source channel parameters on this page, move the field-pointer (▶) to the desired field and enter the parameter value with the ENTRY keys. Each time an entry is made the field-pointer will automatically move to the next field, as shown in Figure B. Except for SWEEP MODE, only numeric values and engineering units (m, μ, n, p) can be entered on this page. The source name assigned to each source channel on the CHANNEL DEFINITION page is automatically entered on this page.

Note

Entered value may be automatically changed to acceptable value when the ENTER key is pressed or the page is changed.

Figure 3-22. SOURCE SETUP Page (Sheet 1 of 4).

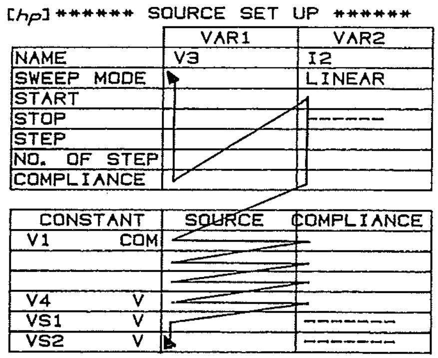


Figure B

Parameter Entry :

When entering numeric values on this page, it is not necessary to enter the value unit. The unit for voltage values is V (volt); for current values, A (ampere); and for time values, s (seconds). For example, the key strokes required to enter a current value of 10.5mA are

[1] [0] [.] [5] [m] [ENTER]

This value, 10.5m, will be displayed on the Keyboard Input Line. When the ENTER key is pressed the entered value will be moved to the field at which the field-pointer is located and the unit A will be automatically entered. Voltage and current limits for the SMUs and voltage sources (Vs) are listed below. Refer to Table 3-6 for specifiable voltage and current.

SMU	Voltage Range	0 to ±100V
	Current Range	0 to ±100mA
Vs	Voltage Range	0 to ±20V

Note

Values can be entered in fixed decimal format or floating decimal format (scientific notation).

SWEEP MODE Selection :

SWEEP MODE can be selected only with the softkeys and only when the field-pointer is in the SWEEP MODE row of the VAR1 column.

LINEAR : Linear staircase sweep at the specified STEP value

LOG 10 :
LOG 25 : } Logarithmic staircase sweep at 10, 25, or 50 measurements per decade
LOG 50 :

Figure 3-22. SOURCE SETUP Page (Sheet 2 of 4).

START, STOP, STEP Values for VAR1 :

START and STOP determine the sweep range for the VAR1 source channel. START value can be less than, equal to, or greater than the STOP value. If LOG has been selected as the SWEEP MODE, START and STOP must have the same signs. If the specified START and STOP values are identical, no sweep is performed and measurement is made at one point only. STEP determines the number of measurement points for LINEAR sweep. If LOG has been selected as the SWEEP MODE, the instrument's operating system software automatically calculates and enters the appropriate STEP value. In LINEAR SWEEP MODE, if the STEP value is greater than the START/STOP range (STEP> |STOP-START|), no sweep is performed and measurement is made at the START value only. NO. OF STEP (number of steps) for VAR1 is automatically calculated by the instrument as

$$\text{NO. OF STEP} = \left|\frac{\text{STOP-START}}{\text{STEP}}\right| + 1 \qquad (3\text{-}2)$$

The START, STOP, and STEP values must be such that NO. OF STEP does not exceed 512. Also, both the START and STOP values for LOG sweep must be greater than zero. Even if zero is entered, it is automatically changed to 1mV or 1pA.

START, STEP, and NO. OF STEP for VAR2 :

START, STEP, and NO. OF STEP (number of steps) determine the sweep range for the VAR2 source channel. VAR2 sweeps are VAR1 dependent; that is, VAR2 is swept one STEP for each complete sweep of VAR1. The maximum NO. OF STEP for VAR2 is 32. When only one monitor channel (SMU or Vm) is used the maximum number of measurement points is

$$\text{Measurement Points} = (\text{NO. OF STEP VAR1}) \times (\text{NO. OF STEP VAR2}) \qquad (3\text{-}3)$$

If the number of measurement points exceeds 570, "Buffer full" will be displayed on the CRT.

RATIO and OFFSET Values for VAR1' :

VAR1' can be swept in unison with VAR1 at a constant RATIO or OFFSET. The output from the VAR1' source channel is calculated as

$$\text{VAR1}' = (\text{RATIO}) \times \text{VAR1} \qquad (3\text{-}4)$$
$$\text{VAR1}' = \text{VAR1} + (\text{OFFSET}) \qquad (3\text{-}5)$$

To enter RATIO and OFFSET, move the field-pointer to area 2 or 3 in Figure C, press the VAR1' RATIO or VAR1' OFFSET softkey, enter the desired value, and press EXECUTE. The entered value will be displayed on the CRT, between the two tables. Both RATIO and OFFSET can be entered, but only the one displayed on this page is valid during measurement.

Note

The specified RATIO or OFFSET values must be such that the VAR1' source channel does not exceed its maximum output (SMU, ±100V; Vs, ±20V). Also, output from VAR1' may lead or lag the VAR1 output by 1ms in V mode and from 4ms to 50ms in I mode. For log sweep measurements, only VAR1' RATIO can be specified.

Figure 3-22. SOURCE SETUP Page (Sheet 3 of 4).

HOLD TIME and DELAY TIME:

HOLD TIME is the initial wait time and the wait time after a VAR2 step change. DELAY TIME is the wait time after VAR1 step change. To enter HOLD TIME and DELAY TIME, move the field-pointer to area ② or ③ in Figure C, press the HOLD TIME or DELAY TIME softkey, enter the desired value, and press EXECUTE.

SOURCE Value for CONSTANT Channels:

The NAME and SOURCE MODE of all source channels that were assigned the CONST SOURCE FCTN on the CHANNEL DEFINITION page are listed in the CONSTANT column on this page. The order in which they are listed is identical to the order on the CHANNEL DEFINITION page. To enter the SOURCE value, move the field-pointer to the desired field, key in the value, and press ENTER. The SOURCE value for a COM source channel is set to 0V by the instrument and cannot be changed.

COMPLIANCE Value:

COMPLIANCE is a special feature for protecting samples against over-voltage or over-current damage. Refer to paragraph 3-27. It limits the current output from a voltage source or the voltage output from a current source. COMPLIANCE for a COM source is set to 105mA by the instrument. The COMPLIANCE for a CONSTANT Vs is 10mA but is not displayed on this page.

Softkey Prompts (SKP):

Depending on the position of the field-pointer, the softkey prompts automatically change. Figure C shows the relationship between the position of field-pointer and softkey prompts.

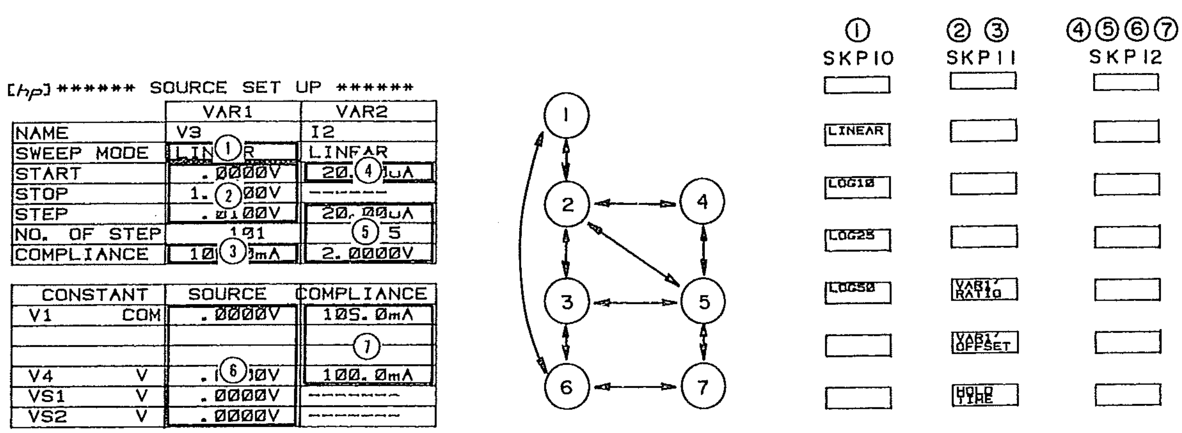


Figure C

Figure 3-22. SOURCE SETUP Page (Sheet 4 of 4).

MEAS & DISP MODE SETUP PAGE

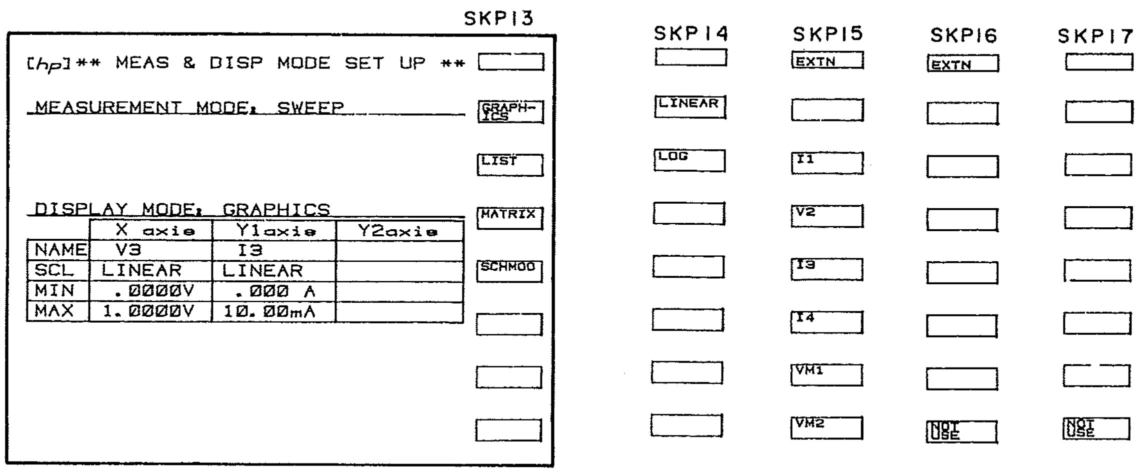


Figure A

Purpose and function of this page :

1. Select the Display Mode for the measurement.
2. Select the monitor channels.
3. Set up the display parameters.

MEASUREMENT MODE:

The existing MEASUREMENT MODE — SWEEP or TIME DOMAIN — is displayed on this page but cannot be changed on this page. MEASUREMENT MODE depends on whether or not VAR1 is assigned to a source channel (SMU or Vs) on the CHANNEL DEFINITION page. If VAR1 is assigned, MEASUREMENT MODE is SWEEP; if not, MEASUREMENT MODE is TIME DOMAIN. Refer to paragraph 3-75 for details on TIME DOMAIN measurements.

DISPLAY MODE Selection :

When this page is initially displayed, the field-pointer (▶) will be located on the DISPLAY MODE line and the display modes — GRAPHICS, LIST, MATRIX, SCHMOO — will be listed in the softkey prompt area of the CRT. The table below the DISPLAY MODE line will change depending on which display mode is selected. The field-pointer will automatically move as names are selected and values are input and the softkey prompts will change depending on the location of the field-pointer.

DISPLAY MODE can be selected only when the field-pointer is on the DISPLAY MODE line. To select the DISPLAY MODE, press the desired softkey. The field-pointer will automatically move to the NAME field of the DISPLAY MODE table.

Figure 3-23. MEAS & DISP MODE SETUP Page (Sheet 1 of 6).

GRAPHICS PLOT Setup:

Pressing the NEXT key when this page is as shown in Figure A will display the GRAPHICS PLOT page, as shown in Figure B. The name and scaling of each axis is determined by the NAME, SCL, MIN, and MAX information appearing on the MEAS/DISP MODE SETUP page.

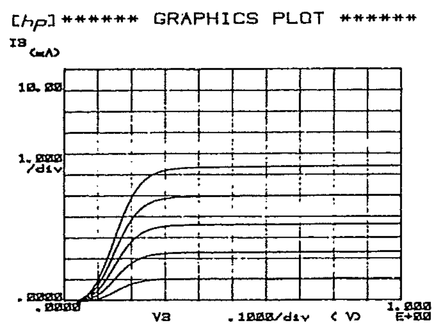


Figure B

NAME: Can be entered only with the softkeys. Determines the channels that will be used in the measurement. Only those channels whose names are listed in the softkey prompt area can be selected. The channel names or user-function names (press EXTN) selected on this page will be X, Y_1, and, if used, Y_2 axes on the GRAPHICS PLOT page.

SCL (Scale): Determines the grid scaling on the GRAPHICS PLOT page. LINEAR or LOG can be selected with the softkeys. Not related to the SWEEP MODE selected on the SOURCE SETUP page.

MIN/MAX: Determines the minimum and maximum values of each axis. Value units (V or A) are automatically entered by the instrument.

Note

MIN and MAX must have the same sign for an axis that is to be displayed with LOG scaling. Also, if 0 is entered for MIN or MAX in LOG scale, 0.1mV, 0.01pA, or 1E-35 is assumed.

GRAPHICS DISPLAY Scaling:

Scaling on the GRAPHICS PLOT page depends on the selected SCL and the MIN and MAX values.

1. When LINEAR has been selected and 0 is not within the MIN/MAX range (i.e., $0 \leq$MIN or MAX≥ 0), MIN and MAX will be located as shown in Figure C.

Figure 3-23. MEAS & DISP MODE SETUP Page (Sheet 2 of 6).

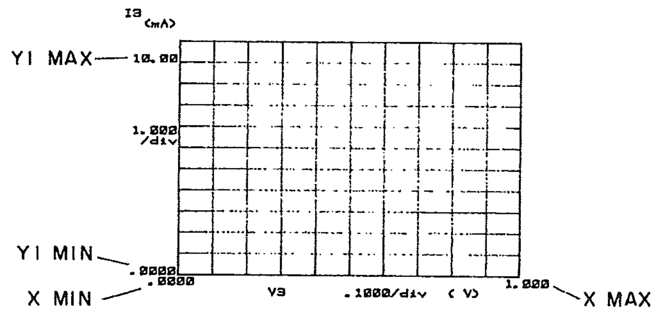


Figure C

When setup for LINEAR scaling, the X axis has 10 divisions and the Y axes, 11. The value per division is calculated as

$$\text{Value/div.} = \frac{|\text{Max-Min}|}{10} \qquad (3\text{-}6)$$

2. When LINEAR has been selected and 0 is within the MIN/MAX range (i.e., MIN<0<MAX), the MIN and MAX values specified on the MEAS/DISP MODE SETUP may be different from those displayed on the GRAPHICS PLOT page. This occurs when the MIN or MAX value is not a multiple of Value/div. in equation 3-6. Division scaling is always in reference to 0. For example if the MIN and MAX values on the MEAS/DISP MODE SETUP page are -.2 and 1, respectively, the MIN and MAX values displayed on the GRAPHICS PLOT page are -.12 and .96, respectively.

3. When LOG has been selected, the number of divisions depends on the number of decades between the MIN and MAX values. For example, when the MIN and MAX values are 1 and 9, respectively, only one division is displayed and the displayed MIN and MAX values are 1E00 and 1E+01; when the MIN and MAX values are 0.9 and 10, respectively, two divisions are displayed and the displayed MIN and MAX values are 1E-01 and 1E+01.

Notes : 1) If Y_1 and Y_2 have different scale modes (SCL), the division lines displayed on the GRAPHICS PLOT page are for Y_1, and Y_2 will have a separate set of tick marks.

2) In LOG scale, an extra decade may be displayed because of the quantum error, and also if the MIN/MAX range is very large, part of the graph will not have division lines.

3) If MIN and MAX are close, their displayed value may include quantum error, and if they are so close that the difference between them is smaller than best resolution, the maximum allowable resolution is used.

1mV (voltage)
50pA (current)
100ms (time)
1E-34 (user function units)

Also, 1 division can not be less than 0.1 in LOG scale :

Figure 3-23. MEAS & DISP MODE SETUP Page (Sheet 3 of 6).

LIST DISPLAY Setup:

When LIST is selected on the DISPLAY MODE line, the MEAS/DISP MODE SETUP page will be as shown below.

[hp] ** MEAS & DISP MODE SET UP **

MEASUREMENT MODE: SWEEP

DISPLAY MODE: LIST

NAMES	IC

Figure D

The field-pointer will be in the top row of the NAMES table. Up to six of the names listed in the softkey prompt area can be entered. Measurement results of each name listed here will be digitally listed on the LIST DISPLAY page. The measurement results are those obtained at each VAR1 step.

MATRIX DISPLAY Setup:

When MATRIX is selected on the DISPLAY MODE line, the MEAS/DISP MODE SETUP page will be as shown below.

[hp] ** MEAS & DISP MODE SET UP **

MEASUREMENT MODE: SWEEP

DISPLAY MODE: MATRIX

NAME	IC

Figure E

The field-pointer will be in the top row of the NAMES table. Only one of the names listed in the softkey prompt area can be entered. Measurement results of the name listed here will be digitally listed on the MATRIX DISPLAY page. The measurement results are those obtained at each VAR1 and VAR2 step.

Note

If VAR2 is not assigned on the CHANNEL DEFINITION page, only one sweep will be made and thus only one set of measurement results will be listed.

Figure 3-23. MEAS & DISP MODE SETUP Page (Sheet 4 of 6).

SCHMOO PLOT Setup:

When SCHMOO is selected on the DISPLAY MODE line, the MEAS/DISP MODE SETUP page will be as shown below.

[hp] ** MEAS & DISP MODE SET UP **

MEASUREMENT MODE: SWEEP

DISPLAY MODE: SCHMOO

NAME		HFE
LIMIT	M	150. E+00
	Δ	140. E+00
	+	130. E+00
	:	120. E+00

Figure F

A SCHMOO PLOT is a three dimensional display, where VAR1 is the X-axis, VAR2 is the Y-axis, and the channel whose name is listed in the NAME field is the Z-axis. When measurement is made, the results are distinguished by the symbols listed in the SCHMOO table. X-axis and Y-axis scaling is determined by the VAR1 and VAR2 sweep parameters. The LIMIT for each symbol is the lower limit. For example, if the LIMITs for M and Δ are .500 and .100, respectively, M represents measurement results greater than .500 and Δ represents measurement results between .100 and .500. For measurement results less than the LIMIT for :, - is used. To enter a LIMIT, move the field-pointer to the M, Δ, +, or : field, enter the value with the ENTRY keys, and press ENTER.

SCHMOO PLOT Scaling:

X and Y axes scaling is determined by the VAR1 and VAR2 sweep parameters. The X-axis can have up to 41 points and the Y axis, up to 21 points. MIN and MAX values for each axis are calculated as follows:

1. SWEEP MODE of VAR1 is LINEAR:

$$\left.\begin{array}{l}\text{X-axis (VAR1): MIN} = a,\ \text{MAX} = a+40\text{x}b \\ \text{Y-axis (VAR2): MIN} = c,\ \text{MAX} = c+20\text{x}d\end{array}\right\} \quad (3\text{-}7)$$

where a = START value of VAR1
b = STEP value of VAR1
c = START value of VAR2
d = STEP value of VAR2

when STEP = 0, MIN and MAX = START.

Figure 3-23. MEAS & DISP MODE SETUP Page (Sheet 5 of 6).

2. SWEEP MODE of VAR1 is LOG:

$$\left.\begin{array}{l}\text{X-axis (VAR1): MIN} = a,\ \text{MAX} = a \times 10^{\frac{40}{\alpha}} \\ \text{Y-axis (VAR2): MIN} = c,\ \text{MAX} = c + 20 \times d\end{array}\right\} \quad (3\text{-}8)$$

where

a = START value of VAR1
α = Number of steps per decade (10, 25, 50)
c = START value of VAR2
d = STEP value of VAR2

Note

Equation 3-8 applies only when START ≦ STOP. When START > STOP, X-axis MAX value is calculated as

$$\text{X-axis: MAX} = a \times 10^{-\frac{40}{\alpha}} \quad (3\text{-}9)$$

Figure 3-23. MEAS & DISP MODE SETUP Page (Sheet 6 of 6).

GRAPHICS PLOT PAGE

SKP18

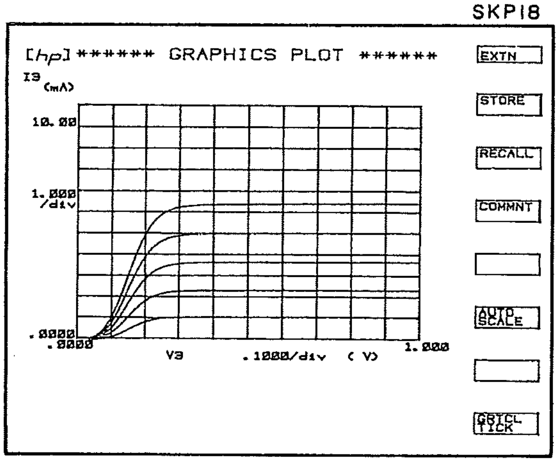


Figure A

Function of this page :

1. Graphically display measurement results.
2. Allow analysis of measurement results with the softkeys and arithmetic capabilities.

MEASUREMENT :

Each time this page is displayed, the results of the previous measurement are automatically re-displayed, regardless of the display mode used in the previous measurement. If any change is made on the CHANNEL DEFINITION page or SOURCE SETUP page or if a NAME on the MEAS/DISP MODE SETUP page is changed, the results of the previous measurement are erased from the data buffer and a new measurement must be made. To make a new measurement, press the SINGLE, REPEAT, or APPEND key. Measurement results will be displayed as the measurement progresses.

Notes : 1) If the X axis value or Y axis value of a measurement point is outside the plot area, no trace will be drawn between it and the previous and succeeding measurement points.

2) In LOG scale, if the measurement data has two polarities, result is not correctly displayed.

3) Only 576 measurement points can be displayed.

Softkey Prompts (SKP) :

Softkey prompts displayed on the GRAPHICS PLOT page are shown in Figure B.

SKP 18 is displayed when this page is first displayed. The other SKPs (19 through 23) can be displayed by pressing the EXTN softkey. When EXTN is pressed on SKP23, SKP18 is displayed. SKP23 (blank) can be used when taking photographs of the CRT.

Figure 3-24. GRAPHICS PLOT Page (Sheet 1 of 6).

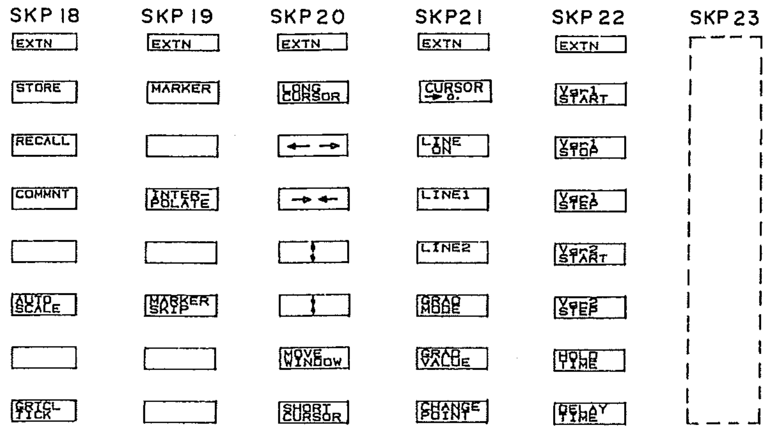


Figure B

Softkey Functions :

STORE : Stores displayed measurement results.

RECALL : Recalls (re-displays) stored measurement results.

These two softkeys provide overlay comparisons of two measurement results. To store the results of a measurement, press the STORE softkey. The frame around the STORE softkey prompt will be highlighted until the data is completely stored, after which it will return to normal intensity. Measurement results are stored in the display buffer as background data, and when recalled, will be of slightly less intensity than normal. Two important points to remember are (1) scaling information is not stored and (2) rescaling is not performed on recalled measurement results, even if the AUTO SCALE function is used. Thus, if the plot to be overlaid is scaled differently from the stored plot, any comparison between the two is meaningless. To recall a stored plot, press the RECALL softkey. The frame around the softkey prompt will be highlighted and will remain so until the softkey is pressed again.

COMMNT :

User-entered comments of up to 30 characters can be displayed on the CRT. The procedure is as follows :

1. Press the COMMNT softkey. The frame around the softkey prompt will be highlighted and the BLUE key will be set to on.

2. Key in the comment (up to 30 characters). There is no restriction on character type.

3. Press the ENTER key. The comment will be displayed directly below the page title and the frame around the COMMNT softkey prompt will be de-highlighted (normal intensity).

With the comment function set to on (COMMNT softkey prompt highlighted), anything displayed on the Keyboard Input Line will be entered and displayed as a comment if the ENTER key is pressed, even if a comment is already displayed below the page title. This allows you to change or delete an existing comment. For example, to delete a comment, press the COMMNT softkey, CLEAR the Keyboard Input Line, and press ENTER.

Figure 3-24. GRAPHICS PLOT Page (Sheet 2 of 6).

AUTO SCALE :

Re-scales the plot area to provide optimum display of the existing measurement results. When auto-scaling is performed, the minimum and maximum measured values are used as the plot-area scaling factors. The MIN and MAX values specified on the MEAS/DISP MODE SETUP page, however, are not changed and the new scaling factors are cancelled when the PREV or MENU key is pressed. To re-scale the existing plot, press the AUTO SCALE softkey. The frame around the softkey prompt will be highlighted and will remain so until auto-scaling is completed, about 5 seconds.

GRTCL TICK :

Graticule or tick mode control. When this softkey is pressed, grid lines are replaced by tick-marks along each axis. To return to graticule mode, press this softkey again.

MARKER :

Displays a marker (◎) which can be moved along plotted curves by rotating the MARKER dial. X, Y_1, and Y_2 coordinates of the marker location are digitally displayed above the plot area. When the Y_2 axis is used, two markers (◎, ∗) are displayed. Both have the same X-axis coordinates and move in unison. The marker can be used for keyboard calculations. Instead of entering the numeric value of a measurement result, the channel name can be entered.

Note

When a log sweep is made, marker location displayed may include quantum error.

INTER-POLATE :

Used for higher resolution marker positioning. Normally the marker moves from one measurement point to the next and cannot be positioned between two measurement points. With the INTERPOLATE function, however, the marker can be positioned at any point between two measurement points.

MARKER SKIP :

Moves the marker or markers to the next VAR2 step. VAR1 does not change. If this softkey is pressed when the marker is at the last VAR2 step, the marker will return to the first VAR2 step. Also, INTERPOLATE is turned off when MARKER SKIP is performed.

Figure 3-24. GRAPHICS PLOT Page (Sheet 3 of 6).

LONG CURSOR :

Displays the LONG CURSOR. When this softkey is pressed, the frame around the softkey prompt will be highlighted and the LONG CURSOR will be displayed at the center of the plot area. The LONG CURSOR can be moved to any point in the plot-area by pressing the appropriate CURSOR keys. Pressing the FAST CURSOR key while pressing one of the directional CURSOR keys moves the cursor faster. The X, Y_1, and Y_2 coordinates of the cursor location are digitally displayed above the plot area. The LONG CURSOR is turned off by pressing this softkey again, by turning on the SHORT CURSOR, or by pressing the PREV or MENU key.

← → : Horizontal zoom-in (x2).

→ ← : Horizontal zoom-out (x2).

↕ : Vertical zoom-in (x2).

↕ : Vertical zoom-out (x2).

These softkeys are used in conjunction with the LONG and SHORT cursors to zoom-in on or zoom-out from the cursor location. When one of these keys is pressed, the cursor will be repositioned at the center of the plot-area and the whole plot-area, including the plotted curves, will be enlarged or reduced in the indicated direction. The relative position of the cursor and plotted curves remains the same. That is, when the cursor is centered by the zoom function, the plotted curves are moved in reference to the cursor. Vertical zooming is performed on the Y_1 -axis only.

MOVE WINDOW :

Moves the LONG CURSOR or SHORT CURSOR to the center of the plot area, maintaining the relative position of the cursor and plotted curves.

SHORT CURSOR :

Displays the SHORT CURSOR. When this softkey is pressed, the frame around the softkey prompt will be highlighted and the SHORT CURSOR will be displayed at the center of the plot-area. The CURSOR can be moved to any point in the plot-area by pressing the appropriate CURSOR keys. Pressing the FAST CURSOR key while pressing one of the directional keys moves the cursor faster. The X, Y_1, and Y_2 coordinates of the cursor location are digitally displayed above the plot area. The SHORT CURSOR is turned off by pressing this softkey again, by turning on the LONG CURSOR, or by pressing the PREV or MENU key.

Note

When the LINE is displayed and either SHORT or LONG CURSOR is on, the location of the CURSOR may change if AUTO-SCALE, ZOOM or MOVE WINDOW is performed.

Figure 3-24. GRAPHICS PLOT Page (Sheet 4 of 6).

CURSOR →○ :

Moves the LONG CURSOR or SHORT CURSOR to the position of the MARKER. MARKER must be turned on.

LINE ON :

Turns on the instrument's graphics analysis functions — LINE 1, LINE 2, GRAD MODE, GRAD VALUE, and CHANGE POINT. When this softkey is pressed, LINE 1 (solid line) and two SHORT CURSORS are displayed. The GRAD, 1/GRAD, X-intercept, and Y-intercept values are also displayed, below the plot area. The graphics analysis functions are available only when this softkey is turned on (frame highlighted).

LINE1 : Displays LINE 1 (solid line)

LINE2 : Displays LINE 2 (dashed line)

Each line has two SHORT CURSORS. One cursor is moveable and the other is fixed. The gradient, or slope, of each line can be changed by moving the moveable cursor with the CURSOR keys. Both lines can be displayed at the same time, but only one (frame highlighted) can be moved. The gradient (GRAD), gradient reciprocal (1/GRAD), X-intercept, and Y-intercept values for both lines are displayed below the plot area. The moveable cursor and fixed cursor can be interchanged by pressing the CHANGE POINT softkey.

GRAD MODE :

Fixed gradient value. When this key is pressed, the fixed cursor is turned off (only the moveable cursor remains), and the line moves at a constant gradient value.

GRAD VALUE :

Line gradient entry. The desired line gradient can be entered from the front panel. When this softkey is pressed, the existing gradient value will be displayed on the Keyboard Input Line. To enter a new value, press the CLEAR key, key in the desired value, and press ENTER. The line will automatically adjust to the new gradient.

CHANGE POINT :

Interchanges the moveable and fixed cursors of the line.

Note

GRAD value and 1/GRAD value display 170E+39 and 5.88E-39 instead of overflow and zero, respectively.

Figure 3-24. GRAPHICS PLOT Page (Sheet 5 of 6).

VAR1 START : Changes the START value for VAR1.

VAR1 STOP : Changes the STOP value for VAR1.

VAR1 STEP : Changes the STEP value for VAR1.

VAR2 START : Changes the START value for VAR2.

VAR2 STEP : Changes the STEP value for VAR2.

HOLD TIME : Changes the HOLD TIME (0 - 655.35 sec).

DELAY TIME : Changes the DELAY TIME (0 - 6.500 sec).

These softkeys allow the operator to check or change the existing measurement parameters, without having to return to the SOURCE SETUP page. The new values are automatically entered on the SOURCE SETUP page. Measurement parameter values can be changed during measurement but only DELAY TIME is valid immediately; HOLD TIME is valid for the next VAR2 step; VAR1 and VAR2 parameters are valid for the next measurement.

Notes

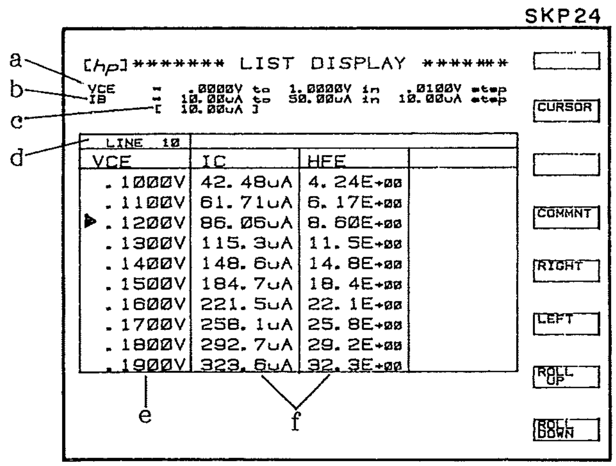
1: Range and resolution are the same as those on the SOURCE SETUP page.

2: Error message "Step overflow" will be displayed when an attempt is made to enter a value that causes the number of steps for VAR1 to exceed 512.

3: VAR1 START, STOP, and STEP softkeys are disabled when VAR1 has not been assigned (e.g., Time Domain measurement), and when VAR1' is assigned VAR2 START and STEP softkeys are disabled when VAR2 has not been assigned. VAR1 STEP is disabled in log sweeps. Also, HOLD TIME and DELAY TIME are disabled in Time Domain measurements.

Figure 3-24. GRAPHICS PLOT Page (Sheet 6 of 6).

LIST DISPLAY PAGE



a. VAR1 START, STOP, STEP values

b. VAR2 START, STOP, STEP values

c. VAR2 value for measurement results in the top row of the list

d. Line number of the measurement results in the top row of the list

e. VAR1 step values

f. Measurement results obtained at each VAR1 and VAR2 step

Figure A

Function of this page :

1. Display the measurement results obtained at each VAR1 and VAR2 (if used) step for all monitor channels selected on the MEAS/DISP MODE SETUP page.

2. Allow analysis of measurement results with the softkeys and arithmetic capabilities.

MEASUREMENT :

Each time this page is displayed, the results of the previous measurement are automatically re-displayed, regardless of the display mode used in the previous measurement. If any change is made on the CHANNEL DEFINITION page or SOURCE SETUP page or if a NAME on the MEAS/DISP MODE SETUP page is changed, the results of the previous measurement are erased from the data buffer and a new measurement must be made. To make a new measurement, press the SINGLE, REPEAT, or APPEND key. Measurement results of the first three monitor channels selected on the MEAS/DISP MODE SETUP page will be displayed as the measurement progresses. The list contains four columns. Each VAR1 step is listed in the left-most column. The VAR2 STEP corresponding to the top line VAR1 STEP is displayed in brackets above the list (c in Figure A). The remaining three columns list the measurement results of the first three monitor channels selected on the MEAS/DISP MODE SETUP page. If more than three monitor channels are selected on the MEAS/DISP MODE SETUP page, measurement results for the fourth, fifth, and sixth monitor channels can be displayed by pressing the LEFT softkey. Only ten lines can be displayed. To display additional lines, use the ROLL UP or ROLL DOWN softkeys.

Figure 3-25. LIST DISPLAY Page (Sheet 1 of 3).

DISPLAY:

Measurement results are displayed in a 3x10 "window", as shown in Figure B. The "field" can be moved left, right, up, or down by pressing the LEFT, RIGHT, ROLL UP, or ROLL DOWN softkey to view other measurement results.

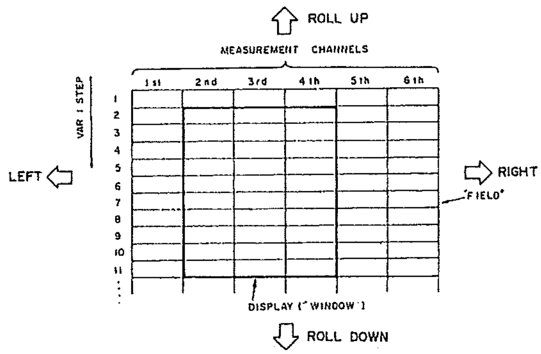


Figure B

Softkey Functions:

This page has only one softkey prompt (shown in Figure A). The function of each softkey is described below.

[CURSOR] :

Turns on the line cursor (▶). When this softkey is pressed, the cursor will be displayed in the VAR1 column and it can be moved up or down with the CURSOR keys. The cursor is used when making keyboard calculations. Instead of entering the numeric value of a measurement result or VAR1 or VAR2 step, the channel name can be used in arithmetic expressions. Using the values listed in Figure A, suppose you want to calculate the square roof of IC when VCE is .1200V. Simply move the cursor down the VCE column and stop at VCE = .1200V, then key in

[√] [I] [C] [EXECUTE]

The square root of 86.06μA will then be displayed on the Keyboard Input Line.

Figure 3-25. LIST DISPLAY Page (Sheet 2 of 3).

COMMNT :

User-entered comments of up to 30 characters can be displayed on the CRT. The procedure is as follows :

1. Press the COMMNT softkey. The frame around the softkey prompt will be highlighted and the BLUE key will be set to on.

2. Key in the comment (up to 30 characters). There is no restriction on character type.

3. Press the ENTER key. The comment will be displayed directly below the page title and the frame around the COMMNT softkey prompt will be de-highlighted (normal intensity).

With the comment function set to on (COMMNT softkey prompt highlighted), anything displayed on the Keyboard Input Line will be entered and displayed as a comment if the ENTER key is pressed, even if a comment is already displayed below the page title. This allows you to change or delete an existing comment. For example, to delete a comment, press the COMMNT softkey, CLEAR the Keyboard Input Line, and press ENTER.

RIGHT : Shifts the monitor channel columns to the right.

LEFT : Shifts the monitor channel columns to the left.

ROLL UP : Rolls the list up.

ROLL DOWN : Rolls the list down.

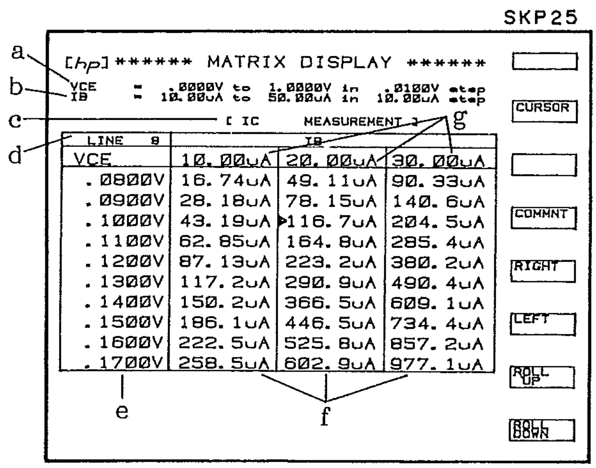
These softkeys allow the operator to view all measurement results. (Refer to Figure B.) When the ROLL UP or ROLL DOWN softkey is pressed and held, line movement is continuous.

Note

When ROLL UP/DOWN is performed during measurement which has more than 100 steps, displayed values may include rounding errors.

Figure 3-25. LIST DISPLAY Page (Sheet 3 of 3).

MATRIX DISPLAY PAGE



a. VAR1 START, STOP, STEP values

b. VAR2 START, STOP, STEP values

c. Monitor Channel or User Function NAME

d. Line number of the top line

e. VAR1 step values

f. Measurement results obtained at each VAR1 and VAR2 step

g. VAR2 step values

Figure A

Function of this page :

1. Display the measurement results obtained at each VAR1 and VAR2 step for the monitor channel selected on the MEAS/DISP MODE SETUP page.

2. Allow analysis of measurement results with the softkeys and arithmetic capabilities.

MEASUREMENT :

Each time this page is displayed, the results of the previous measurement are automatically re-displayed, regardless of the display mode used in the previous measurement. If any change is made on the CHANNEL DEFINITION page or SOURCE SETUP page or if NAME on the MEAS/DISP MODE SETUP page is changed, the results of the previous measurement are erased from the data buffer and a new measurement must be made. To make a new measurement, press the SINGLE, or REPEAT, key. Measurement results of the monitor channel selected on the MEAS/DISP MODE SETUP page will be displayed as the measurement progresses. Results are displayed for each VAR1 step (e in Figure A) and VAR2 step (f in Figure A). Only three VAR2 steps and ten VAR1 steps can be displayed at one time. Measurement results not displayed can be viewed by pressing the LEFT, RIGHT, ROLL UP, or ROLL DOWN softkey.

Figure 3-26. MATRIX DISPLAY Page (Sheet 1 of 2).

DISPLAY:

Measurement results are displayed in a 3 x 10 "window," as shown in Figure B. The "field" can be moved left, right, up, or down by pressing the LEFT, RIGHT, ROLL UP, or ROLL DOWN softkeys to view other measurement results.

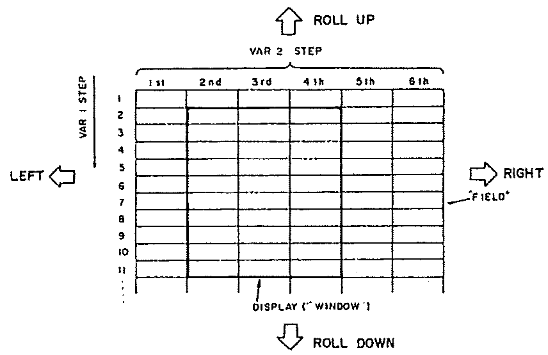


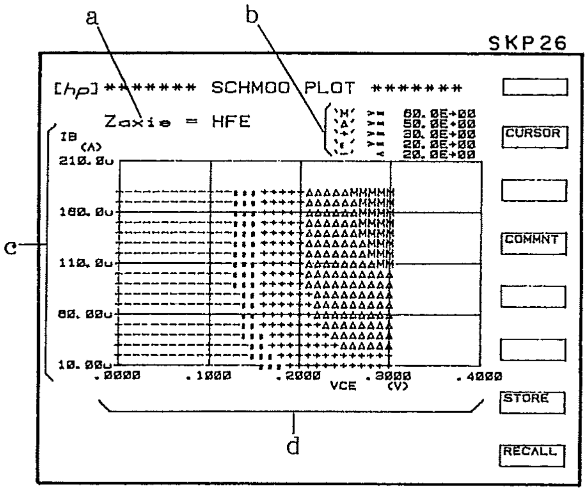
Figure B

Softkey Prompts:

This page has only one softkey prompt (shown in Figure A). Refer to the Softkey Functions description given in Figure 3-25 for the function of each softkey.

Figure 3-26. MATRIX DISPLAY Page (Sheet 2 of 2).

SCHMOO PLOT PAGE



a. Monitor channel name selected on the MEAS/DISP MODE SETUP.

b. Limits specified on the MEAS/DISP MODE SETUP page.

c. VAR2 source name

d. VAR1 source name

Figure A

Function of this page :

1. Plot measurement results on an X-Y-Z graph.
2. Allow analysis of measurement results with the softkeys and arithmetic capabilities.

MEASUREMENT:

To make a measurement, press the SINGLE or REPEAT key (APPEND can not be used). Measurement results will be displayed as the measurement progresses.

Figure 3-27. SCHMOO PLOT Page (Sheet 1 of 3).

X-Axis and Y-Axis Scaling :

Scaling for the X and Y axes is determined by the START and STEP values of VAR1 and VAR2 and by the VAR1 SWEEP MODE. The maximum number of measurement points along the X-axis is 41; along the Y-axis, 21. However, 41x21 measurement points cannot be displayed, because the display buffer can hold only 575 measurement points.

1. Linear VAR1 Sweep :

X-axis (VAR1) : Min. = a, Max. = a + 40 x b
Y-axis (VAR2) : Min. = c, Max. = c + 20 x d

where
a = VAR1 START value
b = VAR1 STEP value
c = VAR2 START value
d = VAR2 STEP value

Note

STOP value is not used in determining axes scaling. Also, if the VAR1 STEP value or VAR2 STEP value is 0, the minimum and maximum scale values for the respective axis are set to the START value.

2. Logarithmic VAR1 Sweep :

X-axis (VAR1) : Min. = a, Max. = $a \times 10^{\frac{40}{\alpha}}$
Y-axis (VAR2) : Min. = c, Max. = c + 20 x d

where
a = VAR1 START value
α = Number of step per decade (10, 25, or 50)
c = VAR2 START value
d = VAR2 STEP value

Note

If VAR1 START>STOP, the exponent in the equation for X-axis Max. becomes as follows.

$$\text{X-axis Max.} = a \times 10^{-\frac{40}{\alpha}}$$

Figure 3-27. SCHMOO PLOT Page (Sheet 2 of 3).

Softkey Functions :

This page has only one softkey prompt (shown in Figure A). The function of each softkey is described below.

CURSOR :

Similar to the CURSOR on the GRAPHICS PLOT page. The cursor highlights the symbol at a measurement point. To move the cursor, use the CURSOR keys. The cursor can be used to simplify keyboard calculations.

Note

When the cursor is moved to a part of the plot area where there are no symbols, * is displayed and no Z-axis value is displayed.

COMMNT :

Same as the COMMNT softkey on the other display pages.

STORE : Stores displayed measurement results.

RECALL : Replaces displayed measurement results with stored measurement results.

These softkeys are similar to the STORE and RECALL softkeys on the GRAPHICS PLOT page (Figure 3-24). The only difference is that recalled measurement results are not displayed over the existing measurement results; that is, only one set of measurement results is displayed. When the frame around the RECALL softkey prompt is highlighted, only stored measurement results are displayed. Conversely, when the frame is not highlighted only the results of the last measurement are displayed. STORE and RECALL operations on this page are unrelated to those on the GRAPHICS PLOT page. For example, measurement results stored on the GRAPHICS PLOT page cannot be recalled on this page.

Figure 3-27. SCHMOO PLOT Page (Sheet 3 of 3).

AUTO SEQUENCE SETUP PAGE

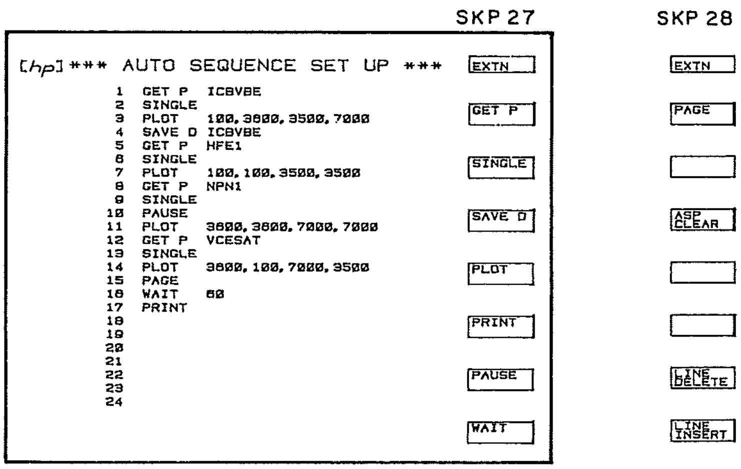


Figure A

Function of this page :

Set up or edit an auto-sequence program.

Auto-Sequence Program :

An auto-sequence program is setup (written) by the operator and can perform a series of instrument operations, without operator assistance. An auto-sequence program can

1. call pre-stored measurement setups from the disc (GET P command),
2. perform a SINGLE measurement (SINGLE command),
3. store measurement results onto the disc (SAVE D command),
4. dump measurement results onto an HP-IB plotter (PLOT command),
5. print out measurement results onto an HP-IB printer (PRINT command),
6. half execution until CONT is pressed (PAUSE command),
7. wait a specified time (WAIT command), and
8. advance the page on an HP-IB plotter (PAGE command).

Figure 3-28. AUTO SEQUENCE SETUP Page (Sheet 1 of 4).

Programming :

Setting up the auto-sequence programs requires no special programming knowledge. When this page is first displayed, the field-pointer will be on line 1 and the auto-sequence commands will be listed in the softkey prompt area of the CRT. To enter a command, simply press the desired softkey. The selected command will be displayed on the line and if the command requires no parameters, the field-pointer will automatically move to the next line. If the command requires parameters (plot area, file name, wait time), the field-pointer will not move, indicating that the operator must enter parameters from the front panel. After the parameters have been keyed in and the ENTER key pressed, the field-pointer will move to the next line. Up to twenty-four lines can be entered. Blank lines are allowed but are ignored during auto-sequence program execution.

Program Commands :

There are eight program commands — GET P, SINGLE, SAVE D, PLOT, PRINT, PAUSE, WAIT, PAGE. They are available with the softkeys only. Each is described below.

[GET P] : GET P file name

This command calls the specified (file name) measurement setup from the disc and displays the display page (GRAPHICS, LIST, MATRIX, or SCHMOO) specified in the measurement setup. To enter this command, press the GET P softkey, key in the desired file name, and press ENTER.

[SINGLE] :

This command executes one measurement. Equivalent to pressing the SINGLE key on the front panel. If SINGLE is entered on line 1 of an auto-sequence program, the program can be executed only on the GRAPHICS PLOT, LIST, MATRIX, or SCHMOO PLOT page. Execution on any other page will result in error Z02. To enter this command, press the SINGLE softkey.

[SAVE D] : SAVE D file name

This command stores measurement results into the specified (file name) data file on the disc. The file name specified in this command must be unique; that is, the file name of an existing data file cannot be used. To enter this command, press the SAVE D softkey, key in the desired file name, and press ENTER.

[PLOT] : PLOT Xmin, Ymin, Xmax, Ymax

This command dumps the existing display (GRAPHICS PLOT, LIST, MATRIX, or SCHMOO PLOT) onto an HP-IB plotter. Scaling parameters (Xmin, Ymin, Xmax, Ymax) must be delimited by a comma or a space. To enter this command, press the PLOT softkey, key in the scaling parameters, and press ENTER.

[PRINT] :

This command outputs measurement results to an HP-IB printer. To enter this command press the PRINT softkey.

Figure 3-28. AUTO SEQUENCE SETUP Page (Sheet 2 of 4).

PAUSE :

This command halts program execution until the CONT key is pressed. While the program is halted, the operator can change paper on the plotter, change test samples, etc. To enter this command, press the PAUSE softkey.

WAIT : WAIT time

This command stops program execution for the specified time. Specifiable time is from 0 to 65535 seconds. Fractional values are rounded to the nearest whole number. To enter this command, press the WAIT softkey, key in the desired wait time, and press ENTER.

PAGE :

This command advances the plotter paper to the top of the next page. The plotter used must be equipped with automatic paper advance.

Program Edit Functions :

There are three program edit functions — ASP CLEAR, LINE DELETE, LINE INSERT. They are available with the softkeys only. Each is described below.

ASP CLEAR :

Clears the entire auto-sequence program and returns the field-pointer to line 1.

LINE DELETE :

Deletes the program line indicated by the field-pointer.

LINE INSERT :

Inserts one blank line between the line at which the field-pointer is located and the preceeding line. The field-pointer remains at the blank line and a new command can be entered. If a line is inserted into a 24-line program, the last line is deleted.

Program Execution :

To execute an auto-sequence program, press the AUTO SEQ START/STOP key. The program will begin and the AUTO SEQ START/STOP indicator lamp will come on. The line number and the command being executed are displayed on the Keyboard Input Line during program execution. The program continues execution until it comes to a PAUSE command or until all lines have been executed. When the program is halted by the PAUSE command, press the AUTO SEQ CONT key to continue the program. To stop the program, press AUTO SEQ START/STOP key again. The indicator lamp will go off and the program will stop at the present line.

Figure 3-28. AUTO SEQUENCE SETUP Page (Sheet 3 of 4).

Note

An auto-sequence program cannot be executed when the instrument is measuring, plotting, printing, or in GL1 mode (under HP-GL control). The AUTO SEQ STOP key cannot be pressed when the auto-sequence program is executing a GET P or SAVE D command.

Note

Once an auto-sequence program containing a SAVE D command is executed, it can not be executed again. If it is executed again, error M05 (file name already reserved) will be displayed on the CRT. To run the auto-sequence program again, change the file name specified in the SAVE D command.

Note

If an error-code ZXX is displayed, the auto-sequence program stops and waits as if a PAUSE command was executed. Refer to Table 3-3 for meaning of the error-code. To continue the program, press the CONT key. The program continues from the next line.

Note

If the length of PLOT command exceeds 26 characters, line number is not displayed when the ASP is executed.

Figure 3-28. AUTO SEQUENCE SETUP Page (Sheet 4 of 4).

OUTPUT SEQUENCE SETUP PAGE

SKP 29

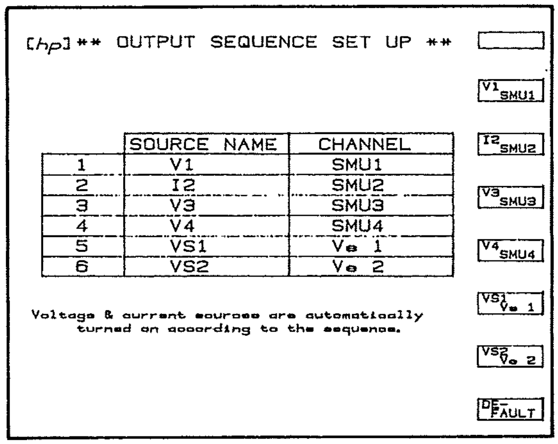


Figure A

Function of this page :

Specify the order in which source channels begin output. When measurement begins, the source channels used in the measurement are turned on in the order specified on this page. The source channels' output sequence is important when measuring devices such as MOSFET transistors or operational amplifier ICs that have FET inputs.

Setup :

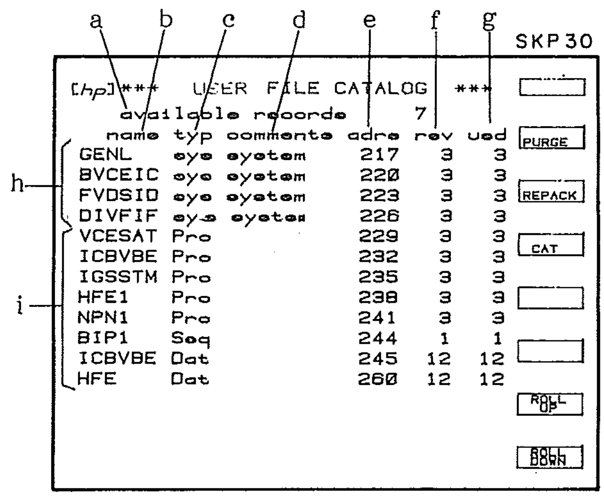
When the instrument is turned on, the output sequence setup is as shown above. To change the setup use the CURSOR keys (to move the field-pointer) and the softkeys.

Note

To include the OUTPUT SEQUENCE SETUP when storing a measurement setup onto the disc, you must return to the MENU after setting up this page. Only then will the new OUTPUT SEQUENCE SETUP be valid for a SAVE P operation.

Figure 3-29. OUTPUT SEQUENCE SETUP Page.

USER FILE CATALOG PAGE



a. Available records
b. File name
c. File type
d. File comments
e. File address
f. Number of records reserved
g. Number of records used
h. System files
i. User-area files

Figure A

Function of this Page :

1. Display information pertaining to files stored on the disc.

2. PURGE (delete) files from the user-area and REPACK the user-area.

Each of the five work-discs furnished with the 4145A has a user-area in which up to 131 records or 96 files can be stored. The number of records per file depends on the file type, as listed below.

Program files (measurement setups)	3rcd/file
Data files (measurement results with setups)	12rcd/file
ASP files (auto-sequence program files)	1rcd/file

Information for up to 12 files can be displayed on this page. To display information on other files, press the ROLL UP or ROLL DOWN softkey. Each item — a through i — in Figure A is described below.

a. Available records :

Shows the number of unreserved records.

b. File name :

Lists the names of all files stored on the disc.

Figure 3-30. 4145A FILE CATALOG Page (Sheet 1 of 3).

c. File type :

Lists the file-type of each file stored on the disc.

Sys : System file
Pro : Program file (measurement setups), file type P
Dat : Data file (measurement results), file type D
Seq : ASP file (auto-sequence program), file type S

When storing or recalling a file, the file type — P, D, or S — must be specified in the SAVE or GET command. System files can be recalled only when the CHANNEL DEFINITION page is displayed and only with the softkeys.

d. File comments :

Lists any comments that were specified in the SAVE command when the file was stored. When specifying a comment in the SAVE command, it must be entered after the file name, must be preceeded by a space, and must not be more than eight characters long.

e. File address :

Shows the address of the first record of each file. The first user-area address is 229. Addresses below 229 are used for operating system software and system files.

f. Number of records reserved :

Shows the number of records reserved for each file. Normally, the number of records reserved is equal to the number of records used, but there are cases when this is not true. For example, if a program file (3 records) is stored after a data file (12 records) has been purged, the new file will have 12 records but will use only 3. The 9 unused records are wasted. They cannot be used for storage of additional files. To delete reserved but unused records, press the REPACK softkey.

g. Number of records used :

Shows the number of records used by each file. This number depends on the file type.

h. System files :

Four general purpose application programs. They can be recalled only when the CHANNEL DEFINITION page is displayed and only with the softkeys. System files cannot be purged.

Figure 3-30. 4145A FILE CATALOG Page (Sheet 2 of 3).

Softkeys :

This page has only one softkey prompt (shown in Figure A). The function of each softkey is described below.

PURGE :

This softkey is for deleting files from the disc. To purge a file, press the PURGE softkey, key in the file type and file name, and press EXECUTE. If the CLEAR key is pressed before EXECUTE, the PURGE operation is cancelled.

REPACK :

This softkey repacks all files in the user-area. Unused records resulting from a PURGE operation are closed. To repack the user-area, press the REPACK softkey and then press EXECUTE. The time required to complete the REPACK operation depends on the number of unused records, ranging from a few seconds to a few minutes.

CAUTION

DO NOT TURN OFF THE INSTRUMENT WHILE REPACK IS BEING PERFORMED. TO DO SO MAY ERASE THE USER-AREA FILES.

Note

When REPACK is performed, the file order may change.

CAT :

If the disc is changed while the FILE CATALOG page is displayed, this softkey displays the FILE CATALOG of the new disc.

ROLL UP :

This softkey rolls-up the file list. If this softkey is pressed and held, continuous roll-up is performed.

ROLL DOWN :

This softkey rolls-down the file list. If this softkey is pressed and held, continuous roll-down is performed.

Figure 3-30. 4145A FILE CATALOG Page (Sheet 3 of 3).

OPERATION GUIDE PAGE

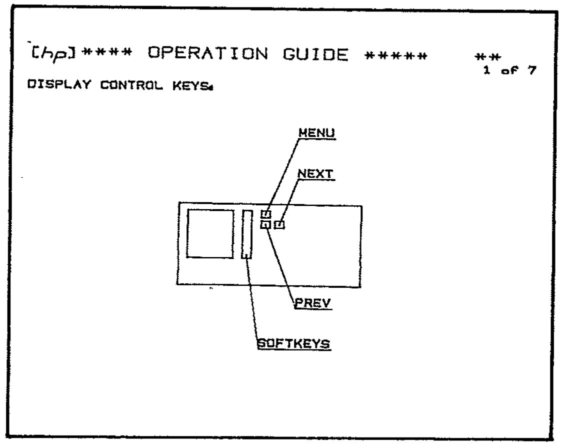


Figure A

Function of this page :

Provide basic operating instructions. Included are descriptions of the display control keys, display relationships, and a list of error messages and error codes. This page has seven screens. To view screens 2 through 7, use the NEXT or PREV key.

Construction :

Screen flow is as shown below. The MENU key can be pressed at any time.

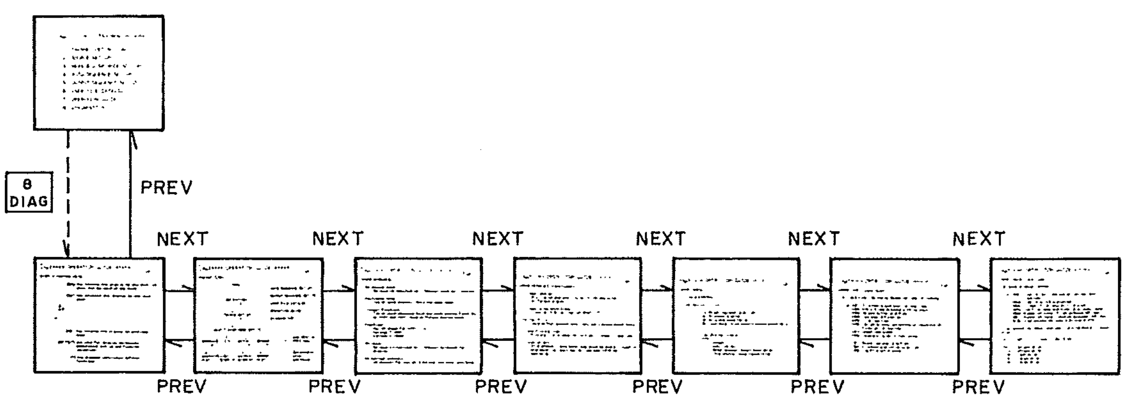


Figure B

Figure 3-31. OPERATION GUIDE Page.

DIAGNOSTICS PAGE

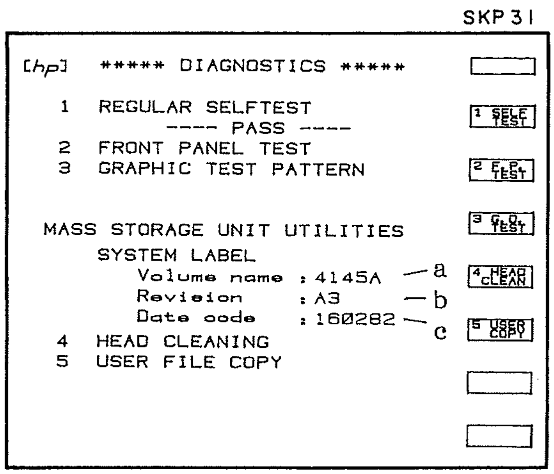


Figure A

a. System name
b. Revision number
c. Software data code

Functions of this page :

1. Display the disc's system label.
2. Perform Disc-Drive Head cleaning.
3. Copy all files in the user-area onto another disc.

Softkey functions :

One Softkey Prompt (SKP31) is displayed on this page.

[1 SELF TEST] : Self Test

Two Self-Tests are performed when this softkey is pressed. They are as follows :

1. MPU Test : Checks the ROMs and RAMs. If an abnormality is detected, an error-code will be displayed in the center of CRT.
2. SMU Test : Checks SMUs 1 through 4 and their control circuit. If an abnormality is detected, CHAN (!!! DOWN !!!) or CHAN (10, 20, 31, 40) will be displayed. In the latter, SMU3 is down.

If the SELF TEST detects an abnormality, contact the nearest Hewlett-Packard Sales or Service Office.

Figure 3-32. DIAGNOSTICS Page (Sheet 1 of 3).

2 F.P. TEST : Front Panel Test

This softkey is used for testing the operation of the front panel controls. When this key is pressed, the display will change to that shown in Figure B and the front panel lamp test will begin. In the lamp test, all lamps on the front panel are momentarily turned on and then turned on one at that time. During the lamp test no keyboard operations can be performed. When the lamp test is completed, the rotary dial test and key test can be performed. To perform the rotary dial (MARKER) test, rotate the dial and observe the COUNT display on the CRT. Rotating the dial clockwise 360 degrees increases COUNT by 120; rotating the dial counterclockwise 360 degrees decreases COUNT by 120. COUNT can be reset to zero by pressing the CLEAR key. In the key test, NEXT KEY shows number of the key that should be pressed next; LAST KEY shows the number of the key that was just pressed. Key numbers are shown in Figure C. To perform this test, press key 1; LAST KEY should change to 1 and NEXT KEY , to 2. Continue in this manner until all the keys have been checked. When key 66 (EXECUTE) is pressed, NEXT KEY and LAST KEY will both be 66, and when key 66 is released, the display will change back to that shown in Figure A.

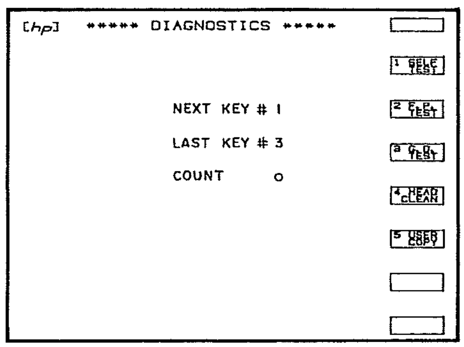


Figure B

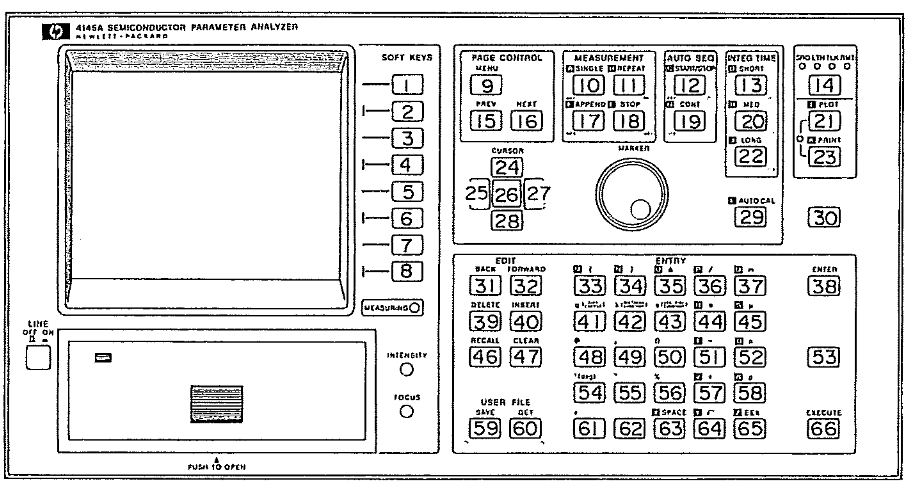


Figure C

Figure 3-32. DIAGNOSTICS Page (Sheet 2 of 3).

3 G.D. TEST : Graphic Display Test

This softkey is used for INTENSITY and FOCUS adjustments. Adjustment procedure is given in Figure 3-6.

4 HEAD CLEAN : Head Cleaning

This softkey provides Disc Drive Head cleaning. The procedure is given in Figure 3-48.

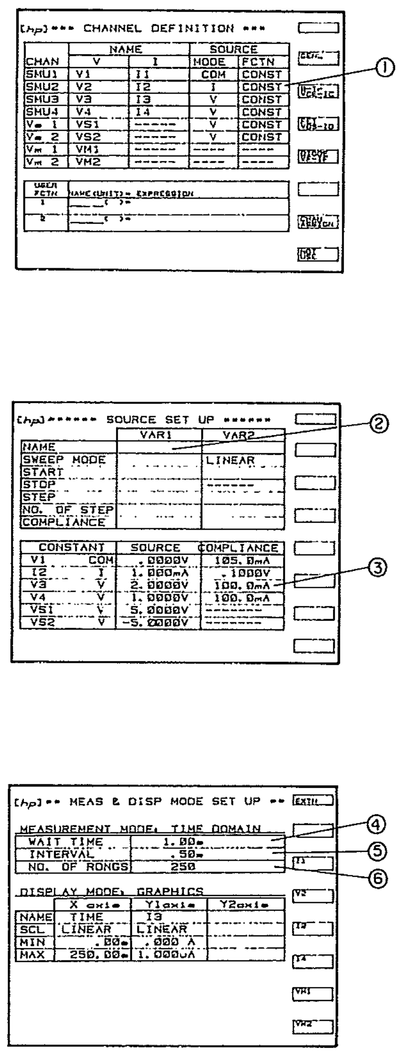
5 USER COPY : User File Copy

This softkey is used for copying the user-area files onto another disc. The procedure is given in Figure 3-47.

Figure 3-32. DIAGNOSTICS Page (Sheet 3 of 3).

3-75. TIME DOMAIN MEASUREMENT SETUP

3-76. The 4145A can measure voltage or current as a function of time. This is called a time domain measurement and is made possible by replacing the main sweep, VAR1, with time. Measurement is made at constant, user-specified time intervals and results can be displayed on the GRAPHICS PLOT, LIST DISPLAY, MATRIX DISPLAY, or SCHMOO PLOT page, just as in a normal VAR1 sweep measurement. (If results are to be displayed on a SCHMOO PLOT, VAR2 must be used.) The page-by-page setup for a typical time domain measurement, along with measurement results, is shown in Figure 3-33.



① Do not select VAR1 as the source function for any of the source channels. VAR2, however, can be selected, if desired. VAR1' can not be used.

② Because VAR1 is not assigned on the CHANNEL DEFINITION page, the VAR1 column on the SOURCE SETUP page is blank.

③ Enter the SOURCE and COMPLIANCE values for each CONSTANT source. If VAR2 is to be used, enter the sweep parameters.

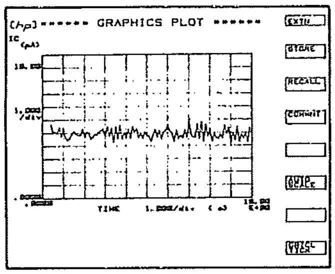
④ WAIT TIME : Identical to the HOLD TIME of a VAR1 sweep measurement. Settable range is 0 to 100 seconds with 10 millisecond resolution.

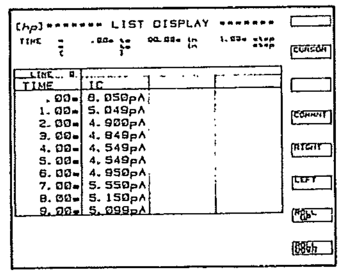
⑤ INTERVAL : The time between measurements. Settable range is .01 to 10 seconds with 10 millisecond resolution.

⑥ NO. OF RDNGS : The number of measurements to be made. If VAR2 is used, this is the number of measurements to be made at each VAR2 step. Settable range is 1 to 512. However, if VAR2 NO. OF STEP x NO. OF RDNGS 570, "buffer full" will be displayed when measurement is made.

Figure 3-33. Time Domain Measurement Setup (Sheet 1 of 2).

Example Measurement





Note

If INTERVAL is too short, error-code (e.g. Error D08) will be displayed. In this case, data is meaningless because the next measurement begins before the present measurement is completed. This meaningless data is not displayed.

Figure 3-33. Time Domain Measurement Setup (Sheet 2 of 2).

3-77 DUT CONNECTION

3-78. DUTs can be connected to the 4145A through the 16058A Test Fixture or through the furnished connector plate (P/N : 04145-60001). Connection using the 16058A is described in paragraph 3-79 and connection using the furnished connector plate, in paragraph 3-81.

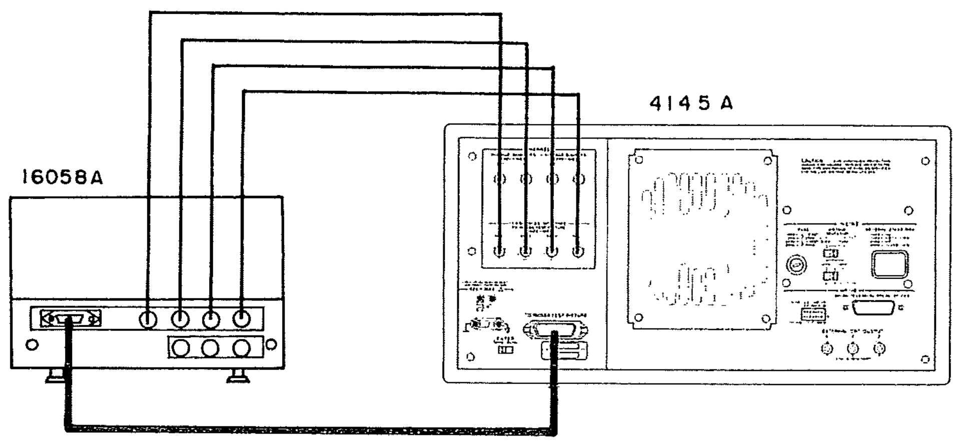
3-79. DUT Connection Using the 16058A

3-80. The 16058A Test Fixture is designed to connect packaged devices, such as transistors, diodes and ICs, to the SMUs, voltage sources, and voltage monitors on the 4145A. Eight different, interchangeable DUT Socket Boards are furnished with the 16058A. Connection between the 4145A and 16058A is shown in Figure 3-34. Also shown are examples using four of the furnished DUT Socket Boards.

The procedure for connecting the 16058A is as follows :

1. Turn off the 4145A. If the 24-pin Shorting Connector (P/N : 04145-61623) is connected to the System Cable connector on the rear panel, remove it.

2. Connect the 16058A to the 4145A as shown below. Use the furnished System Cable (P/N : 16058-61604) and triaxial cables (P/N : 16058-61603). The System Cable contains the Vs lines, Vm lines, and the fixture-lid-open detection line.



CAUTION

THE SYSTEM CABLE CONNECTOR AND THE HP-IB CONNECTOR, BOTH OF WHICH ARE LOCATED ON THE 4145A'S REAR PANEL, ARE IDENTICAL. DO NOT CONNECT THE 16058A TO THE HP-IB CONNECTOR OR THE HP-IB CABLE TO THE 4145A'S SYSTEM CABLE CONNECTOR.

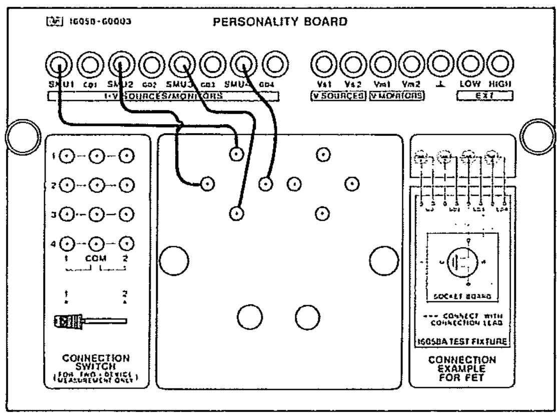
3. Select a DUT Socket Board suitable for the device to be measured, and insert it into the 16058A's Personality Board. To insert the board, pull out the two black fasteners, place the socket board on the Personality Board so that it covers the opening, and press the two black fasteners.

Figure 3-34. DUT Connection Using the 16058A (Sheet 1 of 4).

4. To connect the SMU, Vs, and Vm terminals on the Personality Board to the terminals on the DUT Socket Board, use the furnished connection leads (P/N's : 16058-61600, 16058-61601, and 16058-61602). Examples are given below.

Example 1 : Transistor Socket Board

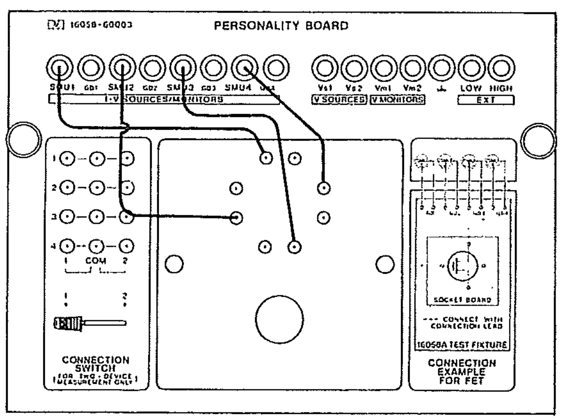
Connect SMUs 1 through 4 directly to terminals 1 through 4, respectively, as shown below.



terminal 1 to SMU1
terminal 2 to SMU2
terminal 3 to SMU3
terminal 4 to SMU4

Example 2 : 8-pin Socket Board

Connect SMUs 1 through 4 directly to terminals 1, 3, 5, and 7, respectively, as shown below.

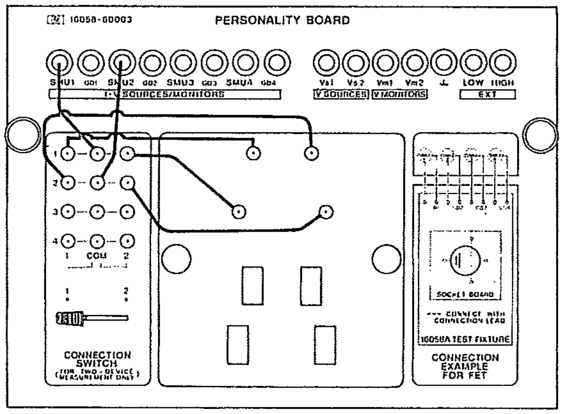


terminal 1 to SMU1
terminal 3 to SMU2
terminal 5 to SMU3
terminal 7 to SMU4

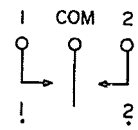
Figure 3-34. DUT Connection Using the 16058A (Sheet 2 of 4).

Example 3 : Using the CONNECTION SWITCH

Connect the Socket Board terminals and SMUs 1 and 2 to the CONNECTION SWITCH, as shown below. When the switch is set to position 1, the SMUs are connected to the top two terminals (NARROW) of the Socket Board and when it sets to position 2, the SMUs are connected to the lower two terminals. When the switch is set to the center position, the Socket Board is not connected to the SMUs.



The Connection Switch is as shown below :



Example 4 : Blank Teflon Board

This board is used when measuring high resistance components or components that can not be measured with the other Socket Boards. To connect the component, use the miniature-clip leads (P/N : 16058-61602).

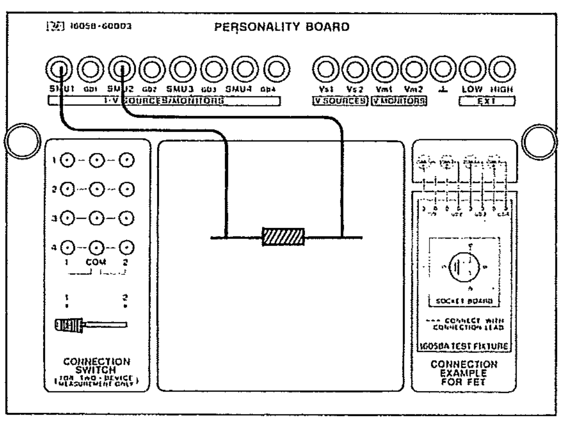


Figure 3-34. DUT Connection Using the 16058A (Sheet 3 of 4).

5. Turn on the 4145A and set up the measurement as required.

6. Close the test fixture lid and press SINGLE, REPEAT, or APPEND to start the measurement.

Note

If the output voltage from an SMU or Vs will exceed ±42V during the measurement, the test fixture lid must be closed to start the measurement. If an attempt is made to start the measurement while the test fixture lid is open, "Close the fixture lid" will be displayed on the CRT and measurement will not begin.

Note

If the test fixture lid is opened during a measurement in which the output voltage exceeds ±42V, measurement will stop immediately and all sources will be turned off (0V) as if the STOP key had been pressed.

7. The figure below shows the connections between the 4145A and the 16058A.

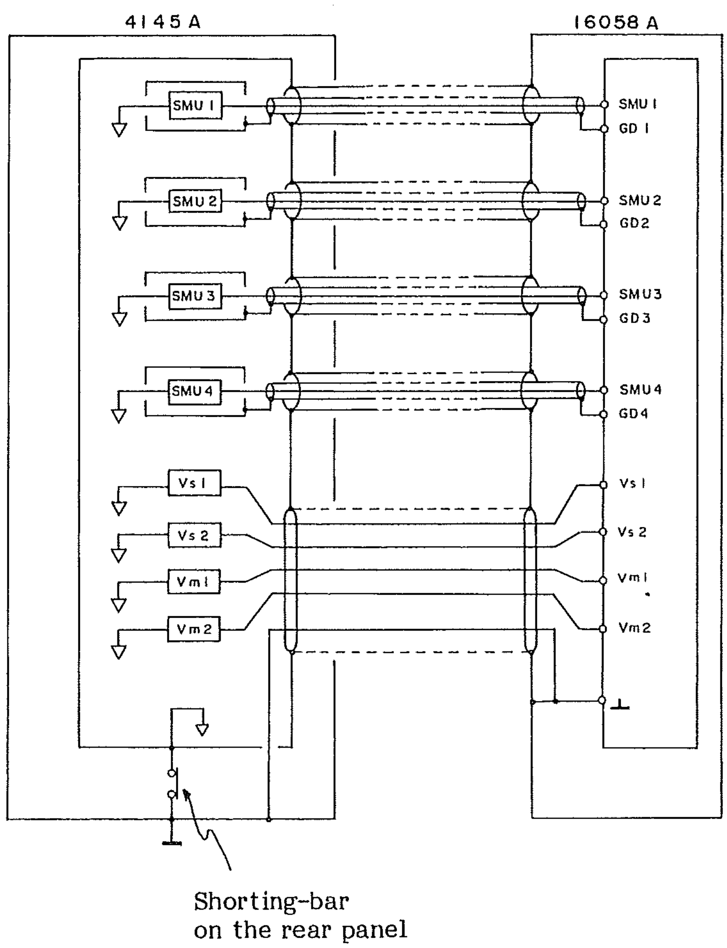


Figure 3-34. DUT Connection Using the 16058A (Sheet 4 of 4).

3-81. DUT Connection Using the Connector Plate

3-82. The furnished connector plate (P/N : 04145-60001) has four BNC connectors and four triaxial connector. It is intended for use with user-fabricated or user-furnished test fixtures. For best measurements results, the test fixture should be enclosed in a shielding-box and the connector plate should be mounted on the box, as shown in Figure 3-35. This significantly reduces the effects of RFI and EMI, and is especially important when making low-current measurements on wafers at the probe station. The procedure for connecting the connector plate, shielding-box and 4145A is given in Figure 3-35.

Mounting the Connector Plate and Connecting the 4145A :

1. Drill the holes required to mount the connector plate onto the shielding-box. Hole spacing is given in Table 1-3.

2. Mount the connector plate on the shielding-box. Make sure there is good electrical contact between the plate and the box.

3. Turn off the 4145A.

4. Connect the furnished 24-pin Shorting Connector (P/N : 04145-61623) to the System Cable connector (labelled TO 16058A TEST FIXTURE) on the rear panel.

Note

If the Shorting Connector is connected, output from the SMUs is not limited to ±42V; that is, the 4145A assumes a fixture-lid-closed condition.

5. Connect the 4145A to the connector plate with the four furnished 3-meter triaxial cables (P/N : 04145-61622) and the four furnished 3-meter BNC cables (P/N : 04145-61630), as shown below.

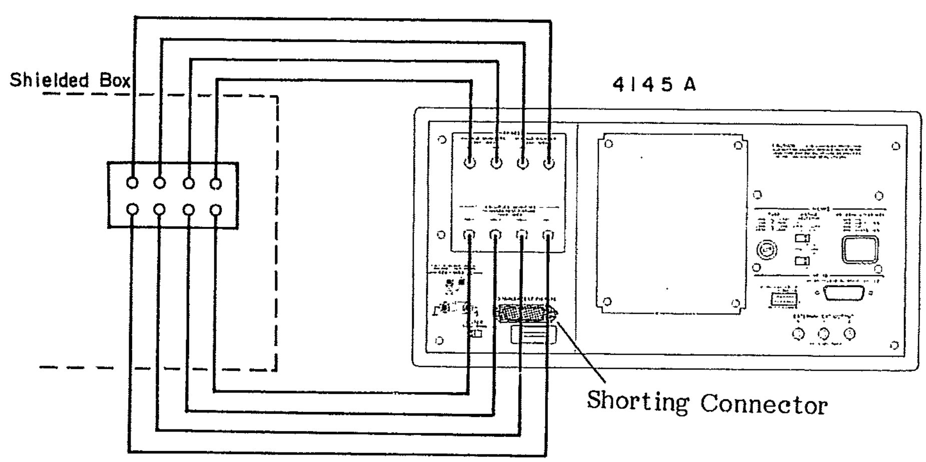
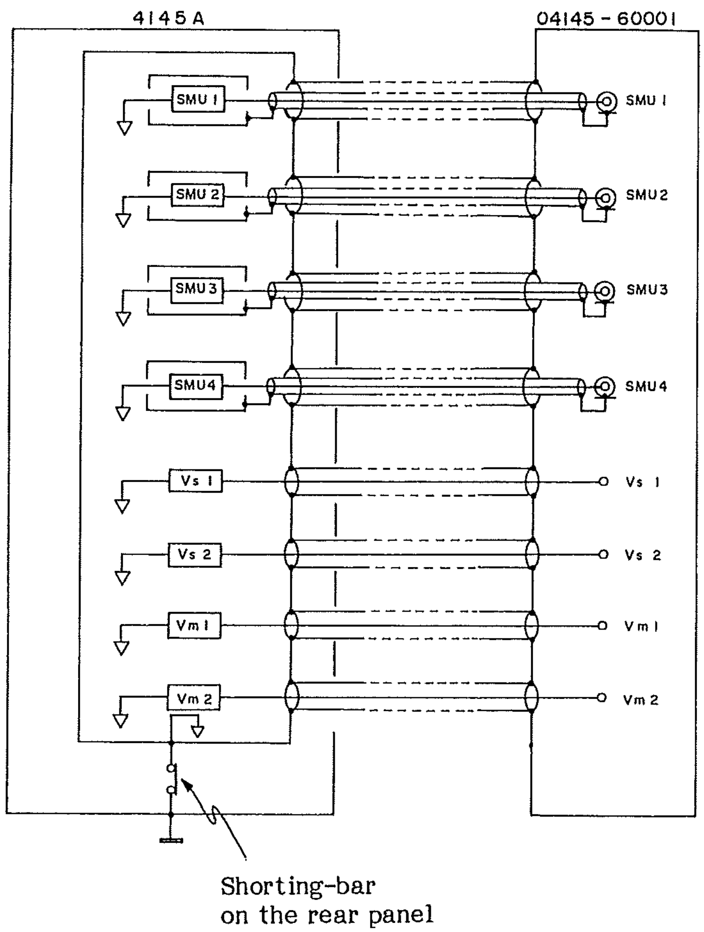


Figure 3-35. DUT Connection Using the Connector Plate (Sheet 1 of 2).

6. Turn on the 4145A and make the necessary measurement setup.

7. The figure below shows the connections between the 4145A and the connector plate.



WARNING

A POTENTIAL SHOCK HAZARD EXISTS WHEN THE SHORTING CONNECTOR IS CONNECTED TO THE 4145A. DO NOT TOUCH THE OUTPUT TERMINAL OR INNER CONDUCTOR OF SMU DURING MEASUREMENT.

Note

Do not connect the inner shield (guard) of an SMU to ground (⊥) or common (⏚).

Figure 3-35. DUT Connection Using the Connector Plate (Sheet 2 of 2).

3-83. FLOATING MEASUREMENT

3-84. When the DUT is grounded or when the external voltage source or shield case for DUT is connected to ground, measurement can not be performed or measurement results may be affected by ground loops. The 4145A can be used for floating measurements by disconnecting the shorting-bar on the rear-panel. In this condition, the measurement and source circuit is floating above chassis ground, and voltages over ±42V may be present on the COM terminal.

WARNING

A POTENTIAL SHOCK HAZARD MAY EXIST WHEN COMMON IS NOT CONNECTED TO GROUND (SHORTING-BAR DISCONNECTED). DO NOT, REGARDLESS OF THE OUTPUT VOLTAGE, TOUCH THE COMMON TERMINAL OR OUTER CONDUCTOR OF THE SMU, Vs, OR Vm CONNECTORS DURING A FLOATING MEASUREMENT (SHORTING-BAR DISCONNECTED).

CAUTION

DO NOT FLOAT THE INSTRUMENT AT VOLTAGES EXCEEDING 42V.

Note

When the 16058A Test Fixture is used, floating measurements can not be made, because source common is connected to chassis ground inside the test fixture.

3-85. GUARDING

3-86. When low-current measurements are made (SMU's set to I monitor), guarding can be used to reduce the effects of leakage current. Voltage at the guard terminal is held at the same potential as the SMU output voltage. Connect the guard terminal (GD1 through 4 terminals on the Personality Board) of the SMU used for I monitor to the outer shield of the DUT. Figure 3-36 shows an example of guarding.

WARNING

GUARD POTENTIAL IS THE SAME AS SMU OUTPUT. DO NOT TOUCH THE GUARD TERMINAL DURING MEASUREMENT.

Note

Do not connect the guard terminal to the common terminal.

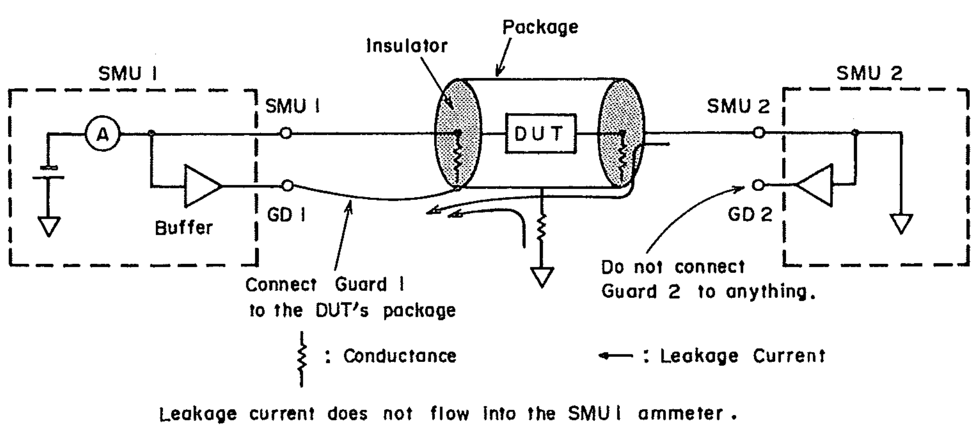


Figure 3-36. Example of Guarding.

3-87. APPLICATIONS PACKAGE

3-88. Each disc furnished with the 4145A contains the following four setups for frequently made measurements:

1. GENL
2. B-Tr VCE-IC
3. FET VDS-ID
4. DIODE VF-IF

When the 4145A is turned on, GENL is automatically loaded. The other furnished measurement setups can be loaded by pressing the appropriate softkey on the CHANNEL DEFINITION page. These furnished setups can not be loaded with the GET command, nor can they be purged from the disc. The contents (channels used, sweep parameters, etc.) of each furnished measurement setup are listed in Table 3-7. Connection examples for each setup are given in Figure 3-37.

Table 3-7. Application Package Setups (Sheet 1 of 2)

	GENL	B-Tr VCE-IC	FET VDS-ID	DIODE VF-IF
SMU 1 (V NAME / I NAME MODE / FCTN)	V1 / I1 COM / CONST	VE / IE COM / CONST	VS / IS COM / CONST	VF / IF V / VAR1
SMU 2 (V NAME / I NAME MODE / FCTN)	V2 / I2 I / VAR2	VB / IB I / VAR2	VDS / ID V / VAR1	——
SMU 3 (V NAME / I NAME MODE / FCTN)	V3 / I3 V / VAR1	VCE / IC V / VAR1	VG / IG V / VAR2	V / I COM / CONST
SMU 4 (V NAME / I NAME MODE / FCTN)	V4 / I4 V / CONST	——	——	——
Vs 1 (NAME / FCTN) Vs 2 (NAME / FCTN)	VS1 / CONST VS2 / CONST	——	——	——
Vm 1 NAME / Vm 2 NAME	VM1 / VM2	——	——	——
USER FUNCTION	——	HFE = IC / IB	——	——

Table 3-7. Application Package Setups (Sheet 2 of 2)

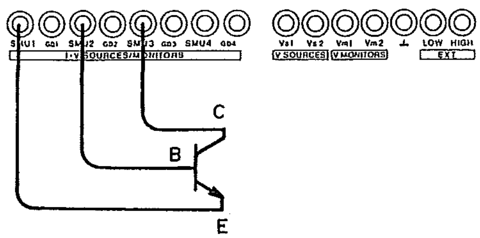
VAR1	SWEEP MODE START STOP STEP COMPLIANCE	LINEAR .000V 1.000V .010V 100.0mA	LINEAR .000V 1.000V .010V 100.0mA	LINEAR −2.5000V 2.5000V .0500V 20.00mA	LINEAR − .5000V 2.0000V .0100V 40.0mA
VAR2	START STEP NO OF STEP COMPLIANCE	20.00 μA 20.00 μA 5 2.0000V	10.00 μA 10.00 μA 5 2.0000V	.0000V −1.0000V 5 1.000mA	———
CONST	NAME SOURCE / COMPLI	V1 0V/105mA	VE 0V/105mA	VS 0V/105mA	V 0V/105mA
	NAME SOURCE / COMPLI	V4 0V / 100mA	——	——	——
	NAME SOURCE / COMPLI	VS1 0V / ---	——	——	——
	NAME SOURCE / COMPLI	VS2 0V / ---	——	——	——
DISPLAY MODE		GRAPHICS			
X axis	NAME SCALE MIN MAX	V3 LINEAR .0000V 1.0000V	VCE LINEAR .0000V 1.0000V	VDS LINEAR −2.5000V 2.5000V	VF LINEAR − .5000V 2.0000V
Y axis	NAME SCALE MIN MAX	I3 LINEAR .000A 10.00mA	IC LINEAR .000A 10.00mA	IG LINEAR .000A 1.000A	IF LINEAR −10.00mA 40.00mA

A. GENL:

General setup assigning all V names and I names.

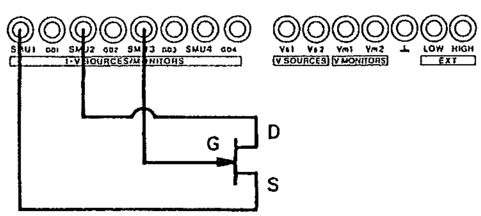
B. B-Tr VCE-IC:

Setup for measurement of NPN bipolar transistors. When the transistor is connected to the 16058A test fixture, as shown below, V_{CE}-I_C (collector/emitter voltage — collector current) characteristics common emitter Bipolar Transistor can be measured. Also, HFE (= IC/IB) is assigned as the User Function.



C. FET VDS-ID:

Setup for measurement of N-channel junction FETs (Field-Effect Transistor). When the FET is connected to the 16058A test fixture, as shown below, V_{DS}-I_D (drain/source voltage — drain current) characteristics of a common drain FET can be measured.



D. DIODE VF-IF:

Setup for measurement of general PN junction diodes. When the diode is connected as shown below, V_F-I_F (forward bias voltage — forward current) characteristics can be measured.

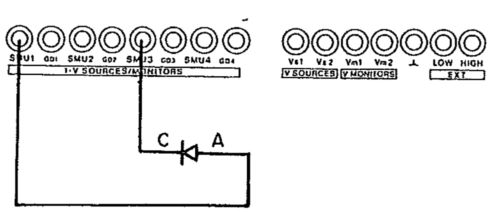


Figure 3-37. Connection Examples for Application Package.

3-89. HP-IB INTERFACE

3-90. The 4145A can be remotely controlled via the HP-IB, a carefully defined instrument interface which simplifies integration of instruments and a calculator or computer into a system.

Note

HP-IB is Hewlett-Packard's implementation of IEEE Std. 488, Standard Digital Interface for Programmable Instrumentation.

3-91. CONNECTION TO HP-IB

3-92. The 4145A can be connected into an HP-IB bus configuration with or without a controller (i.e., with or without an HP calculator). In an HP-IB system without a controller, the instrument functions as a "talk only" device (refer to paragraph 3-117 and 3-119.)

3-93. HP-IB STATUS INDICATORS

3-94. The HP-IB Status Indicators are four LED lamps located on the front panel. When lit, these lamps show the existing status of the 4145A in the HP-IB system as follows :

SRQ : SRQ signal from the 4145A to the controller is on the HP-IB line. Refer to paragraph 3-113.

LISTEN : The 4145A is set to listen.

TALK : The 4145A is set to talk.

REMOTE : The 4145A is under remote control.

3-95. LOCAL KEY

3-96. The LOCAL key releases the 4145A from HP-IB remote control and allows measurement conditions to be set from the front-panel. The REMOTE lamp will go off when this key is pressed. LOCAL control is not available when the 4145A is set to "local lockout" status by the controller.

Note

The 4145A is set to "local lockout" when the 4145A is in GL1 mode.

3-97. HP-IB CONTROL SWITCH

3-98. The HP-IB Control Switch, located on the rear panel, has seven bit switches as shown in Figure 3-38. Each bit has two settings : logical 0 (down position) and logical 1 (up position). The switch has three functions as follows :

(1) Bit switches 1 through 5 (Address Bits) are used to set the HP-IB address (in binary) of the 4145A. Any address between 0 (00000) and 30 (11110) can be set.

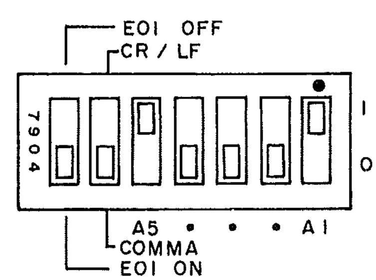
(2) Bit switch 6 (Data Form Bit) determines the output data delimiter. When the bit switch is set to 0, the delimiter is a comma (,); when set to 1, the delimiter is a carriage return and line feed (CR/LF).

(3) Bit switch 7 (EOI; End or Identify) determines whether or not the 4145A sends the EOI signal when data transfer ends.

The HP-IB Control Switch settings are displayed when the 4145A is turned on. Refer to Figure 3-20.

Note

The HP-IB Control Switch, as set at the factory, is shown in Figure 3-38.



Bits 1 through 5: 17
Bit 6: Comma(,)
Bit 7: EOI on

Figure 3-38. HP-IB Control Switch.

3-99. HP-IB INTERFACE CAPABILITIES

3-100. The 4145A has eight HP-IB interface functions. Refer to Table 3-8.

Table 3-8. HP-IB Interface Capabilities

Code	Interface Function* (HP-IB Capabilities)
SH1**	Source Handshake
AH1	Acceptor Handshake
T5	Talker (basic talker, serial poll, talk only mode, unaddress to talk if addressed to listen)
L4	Listener (basic listener, unaddress to listen if addressed to talk)
SR1	Service Request
RL1	Remote/local (with local lockout)
DC1	Device Clear
DT1	Device Trigger
E1	End Message Sending

* Interface functions provide the means for a device to receive, process, and transmit messages over the bus.

** The suffix number of the interface code indicates the limitation of the function capability as defined in Appendix C of IEEE Std. 488.

3-101. HP-IB CONTROL MODES

3-102. When controlled via the HP-IB, the 4145A has two modes :

(1) System Mode :

Setup and measurement is made by a controller via the HP-IB. This is much like manual setup and measurement operation.

(2) User Mode :

Direct control of the CRT and each SMU, Vs, and Vm via the HP-IB. The instrument is set to this mode when program code "US" is sent. Output from each SMU or Vs can be set, and measurement can be made by triggering the desired SMU or Vm. The CRT is blank in this mode, but can be used as a programmable graphics display by sending program code "GL2". To exit from this User Mode (return to System Mode), send a device CLEAR command or a paging command (DE, SS, SM, or MD).

3-103. HP-GL CONTROL OF THE CRT

3-104. The 4145A's CRT can be controlled via the HP-IB by using HP-GL (Hewlett-Packard Graphics Language) commands. There are two HP-GL modes : GL1, which can be used only when the 4145A is operating in System Mode; and GL2, which can be used only in User Mode. Each HP-GL mode is described below.

1. GL1 Mode (Overlay Write):

   This mode is set by sending program code "GL1." It is available only in the System Mode and only on the GRAPHICS PLOT page. In GL1 mode, additional information, such as labels, comments, lines, and curves, can be displayed on graphs plotted by the 4145A. Also, in GL1 mode the 4145A is set to "local lockout."

2. GL2 Mode (Blank):

   This mode is set by sending program code "GL2." It is available only in the User Mode (programming code "US"). In GL2 mode, the CRT is completely independent from the 4145A's CRT control circuit and can be operated as a stand-alone graphics display.

If the display RAM contains too much display data, the 1345A may not be able to complete the display process within one refresh cycle. The display will be incomplete. To exit from the GL1 mode or GL2 mode, send program code "GL0."

To exit from the GL1 mode or GL2 mode, send program code "GL0."

3-105. Remote Program Codes and Parameter Setting

3-106. Figure 3-39 shows the available remote program codes and parameter settings. Program codes are divided into three categories : (1) System Mode program codes, (2) User Mode program codes, and (3) program codes common to both modes. User functions, OUTPUT SEQUENCE, PURGE, REPACK, DISC COPY, and HEAD CLEAN can not be programmed.

Programming notes :

1. Numeric values can be entered in fixed decimal format or floating decimal format. (max. 12 char and max. 2 digits exponent.)

   Example : Fixed decimal : 25.32
   Floating decimal : 2.532E+01

2. Voltage (V), current (A), and time (s) units are not required when entering numeric values.

3. Terminator (; or CR or LF) is required at the end of each parameter setting on a program line. In the examples given below, (TERM) represents the terminator.

4. Channel names must be enclosed in apostrophes (' ').

SYSTEM MODE PROGRAM CODES

Following program codes are used when the 4145A is set to System Mode.

Direct Paging (to change page) :

DE : CHANNEL DEFINITION Page
SS : SOURCE SETUP Page
SM : MEAS & DISP MODE SETUP Page
MD : Display Page (page selected for DISPLAY MODE)
US : User Mode

Notes

1. When the 4145A receives a Direct Paging command, it checks the setup on the displayed page before proceeding to the specified page. If an illegal setup is detected, an error message will be displayed, the SRQ bit will be turned on, and the page will not be changed.

2. Display returns to the MENU page when the 4145A receives a Device Clear command.

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 1 of 9).

CHANNEL DEFINITION Page (program code "DE")

Setup for SMUs 1 through 4

CH $\underset{(1)}{\underline{N^*}}$, $\underset{(2)}{\underline{\text{'XXXXXX'}}}$, $\underset{(3)}{\underline{\text{'XXXXXX'}}}$, $\underset{(4)}{\underline{N}}$, $\underset{(5)}{\underline{N}}$(TERM)

(1) SMU channel number (1 - 4)
(2) V NAME (up to 6 characters)
(3) I NAME (up to 6 characters)
(4) SOURCE MODE (1 - 3)
- 1 : V
- 2 : I
- 3 : COM**

(5) SOURCE FUNCTION (1 - 4)
- 1 : VAR1
- 2 : VAR2
- 3 : CONST
- 4 : VAR1'

* If nothing is specified after the channel number, the channel is turned off (NOT USE).

** When SOURCE MODE is set to 3 (COM), SOURCE FUNCTION must be set to 3 (CONST).

Setup for Vs1 and Vs2

VS $\underset{(1)}{\underline{N^*}}$, $\underset{(2)}{\underline{\text{'XXXXXX'}}}$, $\underset{(3)}{\underline{N}}$(TERM)

(1) Vs channel number (1 or 2)
(2) V NAME (up to 6 characters)
(3) SOURCE FUNCTION (1 - 4)
- 1 : VAR1
- 2 : VAR2
- 3 : CONST
- 4 : VAR1'

* If nothing is specified after the channel number, the channel is turned off (NOT USE).

Setup for Vm1 and Vm2

VM $\underset{(1)}{\underline{N^*}}$, $\underset{(2)}{\underline{\text{'XXXXXX'}}}$(TERM)

(1) Vm channel number (1 or 2)
(2) V NAME (up to 6 characters)

* If nothing is specified after the channel number, the channel is turned off (NOT USE).

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 2 of 9).

SOURCE SETUP Page (program code "SS")

Setup for VAR1

$\underset{(1)}{\underline{XX}}\ \underset{(2)}{\underline{N}},\ \underset{(3)}{\underline{\pm NN.NNN}},\ \underset{(4)}{\underline{\pm N.NNNN}},\ \underset{(5)}{\underline{N.NNNN}},\ \underset{(6)}{\underline{N.NNN}}(TERM)$

(1) SOURCE MODE of VAR1 (VR or IR)
- VR : Voltage Source
- IR : Current Source

(2) SWEEP MODE (1 - 4)
- 1 : LINEAR
- 2 : LOG 10
- 3 : LOG 25
- 4 : LOG 50

(3) START value
(4) STOP value
(5) STEP value*
(6) COMPLIANCE value

* If SWEEP MODE (2) is set to 2, 3, or 4, omit STEP (5).

Setup for VAR2

$\underset{(1)}{\underline{XX}}\ \underset{(2)}{\underline{\pm N.NNNN}},\ \underset{(3)}{\underline{\pm N.NNNN}},\ \underset{(4)}{\underline{NN}},\ \underset{(5)}{\underline{N.NNN}}(TERM)$

(1) SOURCE MODE or the VAR2 (VP or IP)
- VP : Voltage Source
- IP : Current Source

(2) START value
(3) STEP value
(4) Number of steps
(5) COMPLIANCE value

Setup for CONSTANT SMUs

$\underset{(1)}{\underline{XX}}\ \underset{(2)}{\underline{N}},\ \underset{(3)}{\underline{\pm N.NNNN}},\ \underset{(4)}{\underline{N.NNNN}}(TERM)$

(1) SOURCE MODE of the channel (VC or IC)
- VC : Voltage Source
- IC : Current Source

(2) SMU channel number (1 - 4)
(3) Output value
(4) COMPLIANCE value

Setup for CONSTANT Vs

$SC\ \underset{(1)}{\underline{N}},\ \underset{(2)}{\underline{\pm N.NNNN}}(TERM)$

(1) Vs channel number (1 or 2)
(2) Output value

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 3 of 9).

HOLD TIME Setting

HT $\underset{(1)}{\underline{\text{N.NN}}}$(TERM)

(1) HOLD TIME

DELAY TIME Setting

DT $\underset{(1)}{\underline{\text{N.NN}}}$(TERM)

(1) DELAY TIME

VAR1' RATIO/OFFSET Setting

$\underset{(1)}{\underline{\text{XX}}}$ $\underset{(2)}{\underline{\pm\text{N.NN}}}$(TERM)

(1) RATIO/OFFSET (RT or FS)
RT: RATIO
FS: OFFSET
(2) Value

MEAS & DISP MODE SETUP Page (program code "SM")

Time Domain Measurement Setup (only when VAR1 is not selected on the CHANNEL DEFINITION page)

WAIT TIME Setting

WT $\underset{(1)}{\underline{\text{N.NNN}}}$(TERM)

(1) WAIT TIME

INTERVAL Setting

IN $\underset{(1)}{\underline{\text{N.NN}}}$(TERM)

(1) INTERVAL Time

NO. OF RDNGS Setting

NR $\underset{(1)}{\underline{\text{NNN}}}$(TERM)

(1) No. of Readings

DISPLAY MODE Selection
DM1: GRAPHICS
DM2: LIST
DM3: MATRIX
DM4: SCHMOO

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 4 of 9).

Setup for GRAPHICS mode ("DM1")

$\underset{(1)}{\underline{XX}}\ \underset{(2)}{\underline{'XXXXXX'}},\ \underset{(3)}{\underline{N}},\ \underset{(4)}{\underline{\pm N.NNN}},\ \underset{(5)}{\underline{\pm N.NNN}}$(TERM)

(1) AXES
- XN : X axis
- YA : Y1 axis
- YB : Y2 axis*
- XT : X axis for time domain measurement**

(2) Monitor channel NAME for the specified axis (must be one of the monitor channel names specified on the CHANNEL DEFINITION page).
(3) SCALE 1 : LINEAR 2 : LOG
(4) MIN value
(5) MAX value

* Y2 axis is optional.
** For time domain measurements, (2) and (3) should be omitted.

Setup for LIST mode ("DM2")

LI $\underset{(1)}{\underline{'XXXXXX'}},\ \underset{(2)}{\underline{'XXXXXX'}},\ \underset{(3)}{\underline{'XXXXXX'}},\ \underset{(4)}{\underline{'XXXXXX'}},\ \underset{(5)}{\underline{'XXXXXX'}},\ \underset{(6)}{\underline{'XXXXXX'}}$(TERM)

(1) ∿ (6) Monitor channel NAMES. At least one NAME must be specified (must be the monitor channel names specified on the CHANNEL DEFINITION page).

Setup for MATRIX mode ("DM3")

MX $\underset{(1)}{\underline{'XXXXXX'}}$(TERM)

(1) Monitor channel NAME (must be one of the monitor channel names specified on the CHANNEL DEFINITION page).

Setup for SCHMOO mode ("DM4")

SH $\underset{(1)}{\underline{'XXXXXX'}},\ \underset{(2)}{\underline{\pm NN.NN}},\ \underset{(3)}{\underline{\pm NN.NNN}},\ \underset{(4)}{\underline{\pm N.NNNN}},\ \underset{(5)}{\underline{\pm N.NNNN}}$(TERM)

(1) Monitor channel NAME (must be one of the monitor channel names specified on the CHANNEL DEFINITION page).
(2) Minimum value for "M"
(3) Minimum value for "Δ"
(4) Minimum value for "+"
(5) Minimum value for " : "

* If no minimum value is specified for (2), (3), (4), or (5), the corresponding symbol will not be used in the SCHMOO PLOT. A comma (,) must be entered, however.

MEASUREMENT Codes (program code "MD")
- ME1 : SINGLE*
- ME2 : REPEAT
- ME3 : APPEND
- ME4 : STOP

* The GET (Get Execute Trigger) command can be used in place of the ME1 program code. An example of the GET command is the TRIGGER command on the 85A or 9845A.

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 5 of 9).

Following progam codes are valid on any page.

AUTO SEQ codes
AS1 : START
AS2 : CONTINUE
AS3 : STOP

SAVE Function

```
SV 'X  _  XXXX  _  XXXXXX' (TERM)
  (1) (2)  (3) (4)   (5)
```

(1) File type
P : Program file
D : Program/Data file
S : ASP file
(2) Space
(3) File name (up to 6 characters)
(4) Space
(5) Comment (up to 8 characters)

* (4) and (5) are optional.

GET Function

```
GT 'X  _  XXXX' (TERM)
  (1) (2)  (3)
```

(1) File type
(2) Space
(3) File name

Assignment of Data Output Channel

```
DO 'XXXXX'
     (1)
```

(1) Monitor channel NAME (must be one of the monitor channel names specified on the CHANNEL DEFINITION page).

PRINT Function
PR : PRINT function ON*
PF : PRINT function OFF

* Refer to paragraph 3-129 for instructions covering HP-IB controlled plot operations.

Graphics Language (GL1) Mode (only on the GRAPHICS PLOT Page)
GL1 : Graphics Display mode ON
GL0 : Graphics Display mode OFF

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 6 of 9).

USER MODE PROGRAM CODES

Following program codes are used when the 4145A is set to User Mode.

User Mode

US : User mode ON*

* To release the 4145A from this mode, send a page command ("DE", "SS", "SM", or "MD") or a device clear command.

Output command for SMUs

$$\underset{(1)}{\underline{\text{XX}}}\ \underset{(2)}{\underline{\text{N*}}},\ \underset{(3)}{\underline{\text{N}}},\ \underset{(4)}{\underline{\pm\text{N.NNNN}}},\ \underset{(5)}{\underline{\text{N.NNNN}}}\text{(TERM)}$$

(1) SOURCE MODE (DV or DI)
    DV : Voltage Source
    DI : Current Source
(2) SMU channel number (1 - 4)
(3) Output Range
    For voltage source (0 - 3)
    0 : AUTO
    1 : 20V
    2 : 40V
    3 : 100V
    For current source (0 - 9)
    0 : AUTO
    1 : 1nA
    2 : 10nA
    3 : 100nA
    4 : 1μA
    5 : 10μA
    6 : 100μA
    7 : 1mA
    8 : 10mA
    9 : 100mA
(4) Output value
(5) COMPLIANCE value

* If nothing is specified after the channel number, the channel is turned off (NOT USE).

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 7 of 9).

Output command for Vs

$$\text{DS } \underset{(1)}{\underline{N}} , \underset{(2)}{\underline{\pm N.NNNN}}(\text{TERM})$$

(1) Vs channel number (1 or 2)
(2) Output value

Triggering (Measurement)

$$\underset{(1)}{\underline{XX}}\ \underset{(2)}{\underline{N}}$$

(1) Measurement mode of the channel to be triggered
 TV : Voltage Monitor
 TI : Current Monitor
(2) Channel number
 1 : SMU1
 2 : SMU2
 3 : SMU3
 4 : SMU4
 5 : Vm1
 6 : Vm2

Graphics Language (GL2) Mode
 GL2 : Graphic Display mode ON
 GL0 : Graphic Display mode OFF

Note

In User Mode, measurement cannot be performed with the fixture lid open because of the protective function. To perform the measurement without closing the fixture lid, use the Shorting Connector as shown in Figure 3-35.

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 8 of 9).

COMMON PROGRAM CODES

Following program codes are available in the System Mode or in the User Mode.

INTEGRATION TIME
IT1 : SHORT
IT2 : MEDIUM
IT3 : LONG

SELF TEST

SF

Data Ready Service Request
If "DR1" is sent (Data Ready Service Request ON), bit 1 (Data Ready) and bit 7 (RQS) of the 4145A's STATUS BYTE are set to 1 when measurement data is valid.
DR0 : OFF
DR1 : ON

HP-IB Data Buffer Clear
To clear the HP-IB data output buffer and bit 1 (Data Ready) of the Status Byte. Buffer Clear must be performed before data output from the 4145A.
BC

Auto Calibration
CA0 : OFF
CA1 : ON*

* Auto calibration in the User Mode is performed only once when "CA1" is sent. Also, if the mode is changed, Auto Calibration is set to OFF.

PLOT function

$$\text{PL } \underbrace{\text{NNN}}_{(1)},\ \underbrace{\text{NNN}}_{(2)},\ \underbrace{\text{NNNN}}_{(3)},\ \underbrace{\text{NNNN}}_{(4)}\text{(TERM)}$$

(1) Xmin
(2) Ymin
(3) Xmax
(4) Ymax

PF : PLOT function OFF

* Refer to paragraph 3-129 for instructions covering HP-IB controlled plot operations.

Figure 3-39. Remote Program Codes and Parameter Setting (Sheet 9 of 9).

3-107. HP-GL COMMANDS

3-108. HP-GL commands that can be used when the 4145A is set to User Mode (refer to paragraph 101) are listed in Table 3-9.

For more detailed information on HP-GL, refer to the operation manual of any HP-IB compatible plotter.

Table 3-9. HP-GL Commands (Sheet 1 of 3)

Code	Name	Meaning	Coding Example *1
VECTOR Group			
PU	Pen Up	Turns off the beam.	PU
PD	Pen Down	Turns on the beam.	PD
PA	Plot Absolute	Moves the beam to the point specified by the X- and Y-coordinates.	PA X -coordinate, Y -coordinate, ... X -coorinate, Y -coordinate
PR	Plot Relative	Moves the beam the specified units.	PR X -increment, Y -increment, ... X -increment, Y -increment
CHARACTER Group			
CS	Designates Standard Character Set	Selects the character set. *2	CS Character Set#
LB	Label	Writes characters using the assigned character set.	LB(Characters) [ETX] *3
DR	Relative Direction	Selects the writingdirection. *4 $(-128 \leqq \frac{run}{rise} \leqq 127)$	DR run, rise
SR	Relative Character Size	Selects the character size. *5	SR width, height.
CP	Character Plot	Moves the beam the specified of characters. $(-128 \leqq number \leqq 127)$	CP horizontal, vertical
LINE TYPE Group			
LT	Line Type	Selects the line type.	LT pattern number *6
SP	Pen Select	Selects the beam intensity.	SP intensity number *7
VS	Velocity Select	Selects the beam writing speed.	VS velocity *8 , beam intensity number.
AXES Group *9			
XT	X Tick	Writes an X-axis tick mark at the present beam position	XT
YT	Y Tick	Writes a Y-axis tick mark at the present beam position.	YT
SETUP Group *10			
IP	Input P1 and P2 P2	Sets up the scaling points, P1 and P2.	IP Plx, Ply, P2x, P2y
OP	Output P1 and P2	Outputs the scaling points.	OP
IW	Input Window	Limits the plot area.	IW X_{LL}, Y_{LL}, X_{UR}, Y_{UR}

Table 3-9. HP-GL Commands (Sheet 2 of 3)

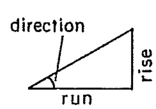
Code	Name	Meaning	Coding Example *1
CONFIGURATION and STATUS Group			
DF	Default	Returns the CRT setup to the default condition. *11	DF
IN	Initialize	Returns to the default condition and clears the display.	IN
IM	Input Mask	Selects mask value of the error number *12 which can cause an SRQ.	IM mask value
OE	Output Error	Outputs the error number *12 that caused an SRQ.	OE
OS	Output Status	Outputs the CRT's status byte. *13	OS
ORIGINAL INSTRUCTION Group *14			
MA	Memory Address	Sets the memory pointer to the specified address.	MA address number
MJ	Memory Jump	Sets the "Memory Jump" command to the address.	MJ jump address
MC	Memory Count	Outputs the memory count to which the memory pointer points.	MC
MK	Memory Clear	Clears the user memory and resets the memory pointer.	MK
PG	Page	= MK(Memory Clear)	PG
AF	Advance Full Page	= MK(Memory Clear)	AF

*1 Terminater (; or LF) is required at the end of each command.

*2 Only one Character set is available on the 4145A.

*3 Indicated Label Terminator (use ASCII CODE ETX).
Example for LB command sent by HP85 (displays 4145A)
OUTPUT 717; "LB 4145A" & CHR $ (3)

*4 All run and rise values are converted into 0°, 90°, 180° or 270° as follows:



$-45° \leq$ direction $\leq 45° \longrightarrow 0°$
$45° <$ direction $< 135° \longrightarrow 90°$
$135° \leq$ direction $\leq 225° \longrightarrow 180°$
$225° <$ direction $< 315° \longrightarrow 270°$

*5 Four character sizes (x1.0, x1.5, x2.0, and x2.5) are selectable according to larger value of width or height as follows:
$0 \leq$ larger value $< 3 \longrightarrow$ x1.0 size
$3 \leq$ larger value $< 4 \longrightarrow$ x1.5 size
$4 \leq$ larger value $< 5 \longrightarrow$ x2.0 size
$5 \leq$ larger value $\leq 127 \longrightarrow$ x2.5 size

*6 Four line types are selectable as follows:
0: Line with dot at the last point
1 or 2: Short dashed line
3 ∿ 6: Long dashed line
7: Solid line

*7 Four beam intensities are selectable as follows:
0: Blank
1: Dim
2: Half brightness
3: Full brightness

Table 3-9. HP-GL Commands (Sheet 3 of 3)

*8 Four beam speeds are selectable as follows:

5: 0.05 inch/μsec
10: 0.10 inch/μsec
15: 0.15 inch/μsec
20: 0.20 inch/μsec

*9 Tick length is fixed at 0.8% of |P2x - P1x| or |P2y - P1y|.

*10 IP, OP, and IW are fixed at P1 = (0,0), P2 = (2047, 2047). Also, the limits of the GRAPHICS PLOT page is LL = (220, 493), UR = (1570, 1725)

*11 Default condition is as follows:

DR	Relative Direction	:	0°
SR	Relative Character Size	:	X1 size
LT	Line Type	:	Solid line
SP	Pen Select	:	Full brightness
VS	Velocity Select	:	0.20 inch/μsec
IM	Input Mask	:	225

*12 Error number that occurs first is output. Error meanings are as follows:

1: Instruction is not recognized (mask value=1)
2: Wrong number of parameter (mask value=2)
3: Bad parameter (mask value=4)
4: Illegal character (mask value=8)
7: All of the display memory has been used (mask value=64)

*13 Status values output from the CRT status byte have the following meanings (more than one may exist):

1: Beam is ON
8: Initialized
32: Error

*14 ORIGINAL INSTRUCTION Group controls the vector memory using the memory pointer. The vector memory outputs (to the CRT) the display data at the address designated by the memory pointer. The memory pointer scans the vecter memory. Using "MA", "MJ", "MC", and "MK", the display can be controlled. Available memory addresses are 2453 through 4094 in GL1 mode, and 410 through 4094 in GL2 mode.

3-109. DEVICE CLEAR

3-110. The 4145A's control settings return to the initial control settings described in paragraph 3-14 when it receives a Selected Device Clear or Group Device Clear.

3-111. DATA OUTPUT

3-112. The 4145A outputs measurement and status data to external devices via the HP-IB. The data output format depends on whether the 4145A is set to System Mode or User Mode. In System Mode, all measurement and status data stored in the data buffer are output when the 4145A receives program code "DO". In user mode, measurement and status data for the triggered channel are output when the 4145A receives program code "DO". The output formats are shown in Figure 3-40.

1. Data Output Format for the System Mode
When the remote program code "DO" is sent, the 4145A outputs data in following format*1.

$$\underbrace{X}_{(1)}\underbrace{\pm NN.NNN}_{(2)}\underbrace{E\pm NN}_{(3)}\underbrace{,}_{(4)}\ X\pm NN.NNNE\pm NN,\ \cdots\cdots\ X\pm NN.NNNE\pm NN\underbrace{(CR)(LF)}_{(5)}$$

(1) Data Status*2
(2) Measurement Data
(3) Exponent*3
(4) Comma (data delimiter)*4
(5) Data Terminator

2. Data Output Format for the User Mode
When the remote program code "TI 'CH#'" or "TV 'CH#'" is sent, the SMU makes a measurement and the 4145A outputs data in the following format.

$$\underbrace{X}_{(1)}\ \underbrace{X}_{(2)}\ \underbrace{X}_{(3)}\underbrace{\pm NN.NNN}_{(4)}\ \underbrace{E\pm NN}_{(5)}\ \underbrace{(CR)(LF)}_{(6)}$$

(1) Data Status*2
(2) Monitor Channel

A : SMU1
B : SMU2
C : SMU3
D : SMU4
E : Vm1
F : Vm2

(3) Measurement mode (V or I)
(4) Measurement data
(5) Exponent*3
(6) Data Terminator

Figure 3-40. Data Output Format (Sheet 1 of 2).

*1 The order of data output is the same as the displayed order.

*2 Data Status indicates the condition of the monitor channel and is output in code, as listed below.

N : Normal
L : INTERVAL is too short.
V : A-D converter saturation
X : Oscillation
C : This channel compliance error
T : Other channel compliance error

Priority is as follows :

L>V>X>C>T>N

*3 Scientific notation is used.

10^{0} .... E+00
10^{-3}(m) E-03
10^{-6}(μ) E-06
10^{-9}(n) E-09
10^{-12}(p) E-12

*4 The delimiter, bit switch 6 on the HP-IB Control Switch (Figure 3-38), is set at the factory to comma (,). This causes the 4145A in the System Mode to output all data as a continuous string. When the data delimiter is set to CR/LF, a carriage return and line feed signal is output after each field. This is useful when outputting data to certain peripherals, such as a strip-printer.

Figure 3-40. Data Output Format (Sheet 2 of 2).

3-113. SERVICE REQUEST STATUS BYTE

3-114. The 4145A outputs an RQS (Request Service) signal whenever bit 1, 2, 3, 4, 6, or 8 of the Service Request Status Byte is set. The make-up of the Status Byte is shown in Figure 3-41.

Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1
Emergency	RQS	Self-Test Fail	Busy	Illegal Program	END Status	Syntax Error	Data Ready

Bit 7 (RQS) indicates whether or not a service request exists. Following are the service request states of the 4145A.

Bit 1 : Data Ready
This bit is set when complete measurement data is ready for output onto the HP-IB. It is reset when data transfer starts or when the 4145A receives program code "BC" (Buffer Clear).

Bit 2 : Syntax Error
This bit is set when the 4145A receives an errorneous remote program code. If this bit is set while bit 8 is set, it has another meaning. Refer to the description for bit 8.

Bit 3 : End Status
This bit is set when Self-Test, PLOT, or PRINT is completed.

Bit 4 : Illegal Program
This bit is set when the 4145A receives an invalid program. If this bit is set while bit 8 is set, it has another meaning. Refer to the description for bit 8.

Bit 5 : Busy
This bit is set when measurement or auto calibration is being performed. It is automatically reset when measurement or calibration ends. This bit does not set the RQS bit.

Bit 6 : Self-Test Fail
This bit is set when Self-Test fails. It is reset when Self-Test is performed again and the result is pass. If this bit is set while bit 8 is set, it has another meaning. Refer to the description for bit 8.

Figure 3-41. Status Byte for the 4145A (Sheet 1 of 2).

Bit 7 : RQS (Request Service)
This bit is set whenever bit 2, 3, 4, 6, or 8 is set. Also set when bit 1 is set if program code "DR1" (Data Ready ON) has been sent.

Bit 8 : Emergency
This bit is set when a potentially dangerous condition exists. The meaning of this bit depends on whether bit 2, bit 4 or bit 6 is set. Each is described below.

Bit 2 : Fixture lid open
This bit and bit 8 are set when the fixture lid is opened during or at the start of a measurement in which the output voltage will exceed ±42V. In user mode, regardless the output voltage, this bit is set if the fixture lid is open or shorting connector is not connected.

Bit 4 : SMU shut down
This bit and bit 8 are set when SMU output is shut down by the instrument to prevent damage to SMU.

Bit 6 : Power Failure
This bit and bit 8 are set when the SMU output was reset by a momentary power loss.

Note

All bits except bit 5 are reset by a Serial Poll, and all bits except bit 1 and 5 are reset by a Device Clear.

Figure 3-41. Status Byte for the 4145A (Sheet 2 of 2).

3-115. Programming Guide for 4145A

3-116. Sample programs for the HP Model 9825B Desktop Computer and HP Model 85A Personal Computer are provided in Figures 3-42 and 3-43, respectively.

Note

1. Specific information for HP-IB programming with the 9825B or 85A is provided in the 9825B or 85A programming manual.

2. Equipment required for these sample programs includes :

   9825B Desktop Computer with 98210A String-Advanced Programming ROM, 98213A General I/O + Extended I/O ROM, and 98034B HP-IB Interface Card.

   85A Personal Computer with 00085-15003 I/O ROM, 00085-15004 Matrix ROM, and 82937A HP-IB Interface Card.

3. Before executing the sample programs, set the HP-IB control switch as follows :

   Address: 17
   Delimiter: comma

4. Before executing sample program 2, close the fixture lid or connect the shorting connecter.

Sample Program 1

Description :

These programs are examples of remote control, data output for a Bi-polar Transistor measurement made in the System Mode. The programs have three capabilities :

(1) Control of the 4145A via the HP-IB
(2) Measurement via the HP-IB
(3) Data output from the 4145A via the HP-IB

9825B Program :

```
 10 : dim A$ [1100]
 20 : wrt717,"IT1 CA1 DR0 BC"
 30 : wrt717, "DE CH1, 'VE', 'IE', 3, 3;
      CH2,'VB','IB',2,2;CH3,'VC','IC',1,1
      CH4"
 40 : wrt717, "VS1; VS2; VM1; VM2"
 50 : wrt717,"SS VR1,0,1,.05,50E-3;IP
      10E-6,10±-6,4,3"
 60 : wrt717,"SM DM1,XN'VC',1,0,1;YA'IC',
      1,0,10E-3"
 70 : wrt717, "MD ME1"
 80 : rds (717)→A
 90 : if bit (0,A)=0;gto 80
100 : wrt 717,"DO 'IC' "
110 : red717,A$
120 : prtA$
130 : end
```

85A Program :

```
10  DIMA$ [1100]
20  OUTPUT717; "IT1 CA1 DR0 BC"
30  OUTPUT717; "DE CH1, 'VE', 'IE', 3,
    3;CH2,'VB','IB',2, 2; CH3, 'VC',
    'IC', 1, 1; CH4"
40  OUTPUT717; "VS1; VS2; VM1; VM2"
50  OUTPUT717;"SS VR1,0,1,.05,50E-3;
    IP 10E-6,10E-6,4,3"
60  OUTPUT717;"SM DM1 XN 'VC',1,0,
    1;YA 'IC',1,0,10E-3"
70  OUTPUT717;"MD ME1"
80  A=SPOLL(717)
90  IF BIT (A,0)=0 THEN 80
100 OUTPUT717;"DO 'IC' "
110 ENTER717;A$
120 DISP A$
130 END
```

These programs perform the following :

Line	Description
10	Define a string variable, A$, to store measurement data.
20	Set measurement integration time (IT1), auto calibration (CA1), data ready (DR0), and data buffer clear (BC).
30/40	Setup the CHANNEL DEFINITION Page (DE).
50	Setup the SOURCE SETUP Page (SS).
60	Setup the MEAS & DISP MODE SETUP Page (SM).
70	Preceed to the GRAPHICS PLOT Page (MD) and perform one measurement (ME1).
80	Read the 4145A's Status Byte and assign the result to variable A.
90	Wait until bit 0 of variable A set to 1 (Data Ready).
100	Send a data output (DO) command to obtain the measurement data from the 'IC' monitor channel.
110	Enter the measurement data into the string variable, A$.
120	Display (85A) or print (9825B) the string variable A$.

Figure 3-42. Sample Program 1 (Sheet 1 of 2).

The proceeding two programs can be modified, as follows, to make overlay plots on the GRAPHICS PLOT Page.

9825B Program :

```
        .
        .
        .
        .
100 :  dim G$ [20]
110 :  wrt 717, "GL1;IN"
120 :  wrt 717, "PA1570, 493;PD;
       PA220, 1725;PU"
130 :  wrt 717,"PA1000, 1000;
       PD; SR0, 3"
140 :  "4145A"→G$
150 :  wrt 717, "LB" & G$
       & char (3)
160 :  wrt 717, "GL0"
170 :  end
```

85A Program :

```
        .
        .
        .
        .
100    DIM G$ [20]
110    OUTPUT717; "GL1;IN"
120    OUTPUT717; "PA1570, 493;PD;
       PA220, 1725;PU"
130    OUTPUT 717; "PA1000, 1000;
       PD; SR0,3"
140    G$ = "4145A"
150    OUTPUT717; "LB" & G$
       & CHR$ (3)
160    OUTPUT717;"GL0"
170    END
```

These program modifications perform the following.

Line	Description
110	Set the 4145A to GL1 mode (GL1), and initialize the CRT (IN).
120	Draw a line from lower right corner to upper left corner of the plot area.
130	Move the beam (PA), and select the character size (SR).
140	Enter the data to be displayed into the string variable G$.
150	PLOT"4145A" (LB).
160	Release the 4145A from GL1 mode.

These program modifications make overlay plots as shown below.

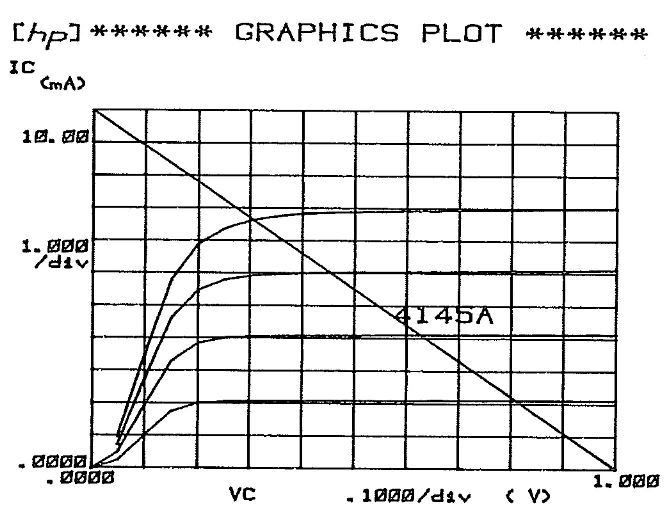


Figure 3-42. Sample Program 1 (Sheet 2 of 2).

Sample Program 2

Description

These programs are examples of remote control, data output in the User Mode. The programs have three capabilities :

(1) Control of an SMU via the HP-IB
(2) Trigger of the SMU via the HP-IB
(3) Data output from the SMU via the HP-IB

Note

Before executing the program, close the fixture lid or connect the Shorting Connecter to the rear panel.

9825B Program :

```
 10 :  dim A$[30]
 20 :  wrt717, "US"
 30 :  wrt717, "IT1CA1 BC"
 40 :  1.5→I
 50 :  wrt717, "DV1, 1," ,I, ",1E-3"
 60 :  wrt717, "DV2, 1, 0, 1E-3"
 70 :  wrt717, "TI1"
 80 :  red717, A$
 90 :  dsp A$
100 :  wrt717, "DV1; DV2"
110 :  end
```

85A Program :

```
 10   DIM A$[30]
 20   OUTPUT717; "US"
 30   OUTPUT717; "IT1 CA1BC"
 40   I = 1.5
 50   OUTPUT717; "DV1, 1," ;I; ",1E-3"
 60   OUTPUT717; "DV2, 1, 0, 1E-3"
 70   OUTPUT717; "TI1"
 80   ENTER717; A$
 90   DISP A$
100   OUTPUT717; "DV1; DV2"
110   END
```

These programs perform the following :

Line	Description
10	Define a string variable, A$, to store measurement data.
20	Set the 4145A to User Mode (US).
30	Set measurement integration time (IT1), auto calibration (CA1), and data buffer clear (BC).
40/50	Set up SMU1 (DV1).
60	Set up SMU2 (DV2).
70	Trigger for I measurement of SMU1 (TI1).
80	Enter measurement data into the string variable, A$.
90	Display the string variable A$.
100	STOP the output for SMU1 and SMU2.

Also, CRT Display can be used as a Graphic Display when program code "GL2" is sent and HP-GL program codes are used, as shown in Figure 3-42.

Figure 3-43. Sample Program 2.

3-117. PLOT

3-118. The 4145A can directly dump an existing display onto an HP-IB plotter, without the aid of a controller. A list of recommended plotters is given in Table 3-10.

Note

Other plotters can be used, but they must have a LISTEN ONLY mode. Also, on some older type plotters, it may not be possible to precisely position alphabetic or numeric strings, such as labels, within a specified plot area.

Table 3-10. Recommended HP-IB Plotters

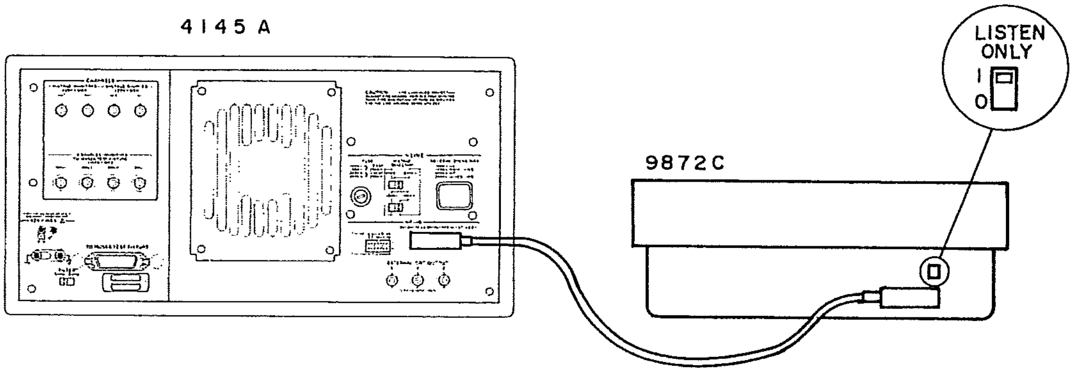
HP7225B	PLOTTER
HP7245B	PLOTTER·PRINTER
HP9872C/T	PLOTTER
HP7580A	PLOTTER

Operating instructions for the PLOT function are given in Figure 3-44.

Connection to the Plotter :

(1) Equipment :
An HP-IB plotter (setable to LISTEN ONLY) and an HP-IB Cable (e.g., 10631B).

(2) Interconnect the 4145A and the plotter as shown below :



(3) Turn off the plotter.

(4) Set the plotter to LISTEN ONLY mode and then turn it on.

Plotting :

(1) Select the desired page. If the GRAPHICS PLOT, LIST DISPLAY, MATRIX DISPLAY, or SCHMOO PLOT page is to be plotted, measurement can be made before the plot.

(2) Press the PLOT key.

(3) The following will be displayed on the Keyboard Input Line.

PLOT	200 ,	200 ,	7400 ,	4800
	Xmin	Ymin	Xmax	Xmax

These values represent the lower-left (Xmin and Ymin) and upper-right (Xmax and Ymax) coordinates of the plot area that was used in the last PLOT operation. (Whenever a PLOT is made, the new plot area parameters are automatically stored on the disc.)

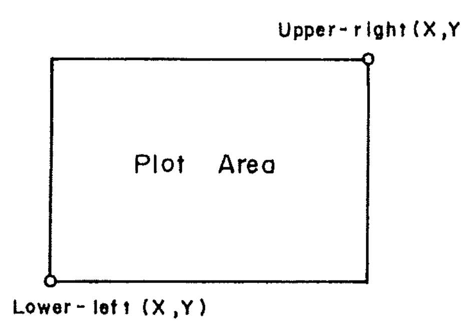


Figure 3-44. Plot Function (Sheet 1 of 2).

Note

The values displayed on the Keyboard Input Line when the PLOT key is pressed are in .025mm units. Note that the maximum value of the X coordinate and Y coordinate for the recommended plotters are different. Refer to the plotter's manual.

(4) If necessary, change the displayed values with the EDIT Keys. ENTER key is not required.) The following limitations must be observed :
   A. Xmin, Ymin, Xmax, and Ymax must not exceed 32767.
   B. The specified plot area must be within the limits of the plotter.
   C. Each value must be delimited by a comma (,) or space.

(5) Press the EXECUTE Key to start plotting. "Plotting" will be displayed on the CRT's System Message Line. During plotting, the 4145A is in TALK ONLY mode, and the TLK lamp (HP-IB status indicators) will be lit. In this condition, only the PLOT or PRINT Key is available. Also, the Xmin, Ymin, Xmax, and Ymax values in effect when the EXECUTE key is pressed are stored on the disc, except when the disc is write-protected.

(6) When the plot is completed, the instrument automatically returns to normal operation mode.

Note

To stop the PLOT, press the PLOT key or PRINT key. If the CLEAR key is pressed before the EXECUTE key is pressed, the PLOT operation will be cancelled. Plotting can not be temporarily stopped.

PLOT Contents :

(1) Following are not plotted.
   A. Softkey Prompts
   B. Data on the Keyboard Input Area
   C. Data on the System Message Line

(2) Following are plotted when measurement data is in the Data Buffer and the CRT is displaying the GRAPHICS PLOT, LIST DISPLAY, MATRIX DISPLAY, or SCHMOO PLOT page.
   A. Setup conditions for VAR1, VAR2, and CONSTANT Sources.
   B. User Function expresions

Pen Selection :

When a multi-color plotter is used, pen # is selected as follows :

Pen #	Used for :
1	Grid Lines
2	Recalled Traces
3	Existing Traces
4	Plot Area Frame, Marker, Cursors, Lines

Note

Refer to paragraph 3-129 for instructions covering HP-IB controlled plot operations.

Figure 3-44. Plot Function (Sheet 2 of 2).

3-119. PRINT

3-120. The 4145A can directly print out measurement data on an HP-IB printer, without the aid of a controller. A list of recommended printers is given in Table 3-11.

Note

The printer must have a LISTEN ONLY mode.

Table 3-11. Reocommended HP-IB Printers

HP9876A	PRINTER
HP2631B/G	PRINTER
HP2671A/G	PRINTER
HP7245B	PLOTTER PRINTER

Operating instructions for the PRINT function are given in Figure 3-45.

Connection to the Printer :
Refer to steps (1) through (4) of "Connection to the Plotter" in Figure 3-44.

Printing :

(1) Press the PRINT key. "PRINT" will be displayed on the Keyboard Input Line.
(2) Press the EXECUTE key to start printing. "Printing" will be displayed on the CRT's System Message Line. During printing, the 4145A is in TALK ONLY mode, and TLK lamp (HP-IB status indicators) will be lit. In this condition, only the PLOT or PRINT key is available.
(3) All measurement data stored in the Data Buffer is printed out.

Note

If no data is in the data buffer, nothing will be printed.

(4) When printing is completed, the instrument automatically returns to normal operation mode.

Note

To stop the PRINT, press the PRINT key or PLOT key. If the CLEAR key is pressed before the EXECUTE key is pressed, the PRINT operation is cancelled. Printing can not be temporarily stopped.

Print Contents :

1. Setup conditions for VAR1, VAR2 and CONSTANT Sources.
2. Measurement data

Note

User functions are not printed out.

Note

Refer to paragraph 3-129 for instructions covering HP-IB controlled plot operations.

Figure 3-45. Print Function.

3-121. EXTERNAL DISPLAY

3-122. The 4145A's CRT is equipped with X-Y-Z analog outputs which can be connected directly to a large screen graphics display. With the X, Y, and Z EXTERNAL CRT OUTPUTS (located on the rear panel) connected to an external display, the displays on the 4145A's CRT will be displayed on the external display also. Recommended external displays are listed in Table 3-12.

Note

The bandwidth of the external display must be at least 2MHz.

Note

Output impedance of the EXTERNAL CRT OUTPUTS is 330Ω (X and Y) and 240Ω (Z). Thus, the input impedance of the external display must be sufficiently higher to obtaian satisfactory display results.

Table 3-12. Recommended External Displays

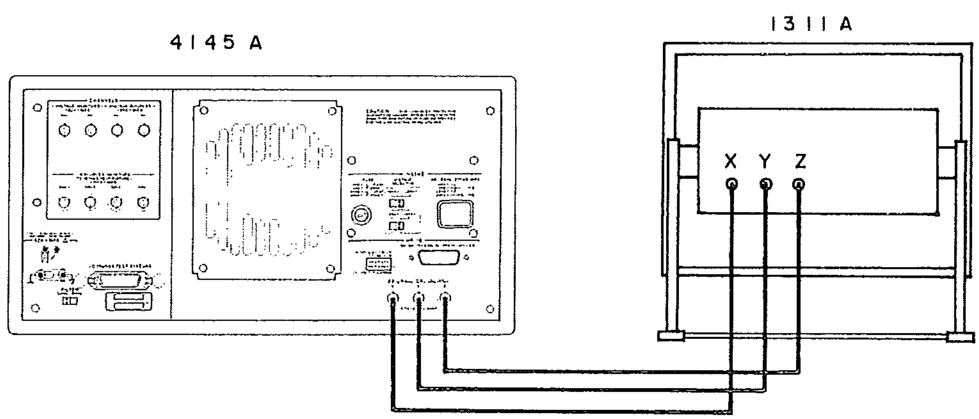
Model No.	Screen Size (HxW)
HP1304A	20cmx25cm
HP1311B	22cmx28cm
HP1317A	26cmx35cm
HP1310B	28cmx38cm
HP1321B	30cmx35cm

Figure 3-46 shows the interconnections between the 4145A and the external display. Details on the X-Y-Z analog outputs are described in the 1345A's operating and service manual.

Connection :

(1) Equipment
External Display (equips X-Y-Z analog inputs) and three BNC-BNC cables

(2) Interconnect the 4145A and External Display as shown below.



(3) In this condition, displays on the 4145A's CRT are also displayed on the external display.

Figure 3-46. External Display.

3-123. DISC COPY

3-124. All files in the user area of a 4145A disc can be copied onto another disc, either one at time or all at once. The procedure is given in Figure 3-47. The operating system software and the system files, however, can not be copied. Also, only 4145A replacement discs (P/N : 04145-61100) can be used.

Note

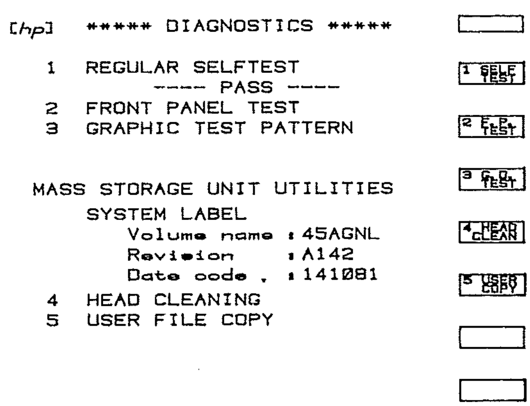
The 4145A is automatically reset after a disc copy operation.

Copy One File :

(1) Load a desired file using the GET function.
(2) Change discs and store the file by using the SAVE function.

Full User Area Copy :

(1) On the MENU page press the DIAGNOSTICS softkey. Display will be as shown below.



(2) Press the USER COPY softkey.
(3) Insert the Master Disc (disc to be copied) and press the CONTINUE softkey. A portion of the user area files will be loaded into the 4145A's RAM. This takes a few seconds.
(4) Insert the Copy Disc (target disc) and press the CONTINUE softkey. The files loaded into the 4145A's RAM in step 3 will be copied onto the disc.
(5) Repeat steps (3) and (4) if instructed to do so.
(6) Copy is finished. To copy additional discs, repeat steps (3) and (4). To return to the initial condition, press the RESET softkey.

Figure 3-47. Disc Copy.

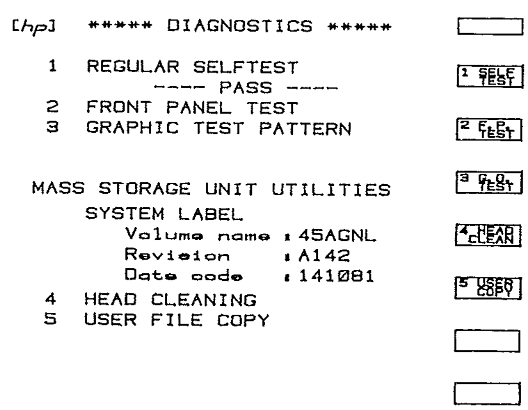
3-125. HEAD CLEANING

3-126. The read/write head in the flexible-disc drive unit should be cleaned every six months. If the 4145A is used in a dusty environment, head cleaning should be performed more frequently. Also, if the instrument does not properly perform the SAVE and GET operations, head cleaning should be performed immediately. The head-cleaning procedure is given in Figure 3-48.

Head Cleaning Procedure

(1) Turn on the 4145A.

(2) Press the DIAGNOSTICS softkey on the MENU Page. Display will be as shown below.



(3) Press the HEAD CLEAN softkey.

(4) Remove the disc and insert the cleaning disc.

(5) Press the HEAD CLEAN softkey again.

(6) Head cleaning takes only a few seconds.

Note

Do not touch the exposed surface of the cleaning disc.

Figure 3-48. Head Cleaning.

3-127. Protection Againt Hazardous Voltage Exceeding ±42V

3-128. To insure operator safety, the 4145A is equipped with a high voltage detect circuit that shuts down the SMUs and voltage sources when a potentially dangerous condition exists. If the lid of the 16058A Test Fixture is not closed at the start of a measurement in which there is a possibility that the voltage output from at least one SMU will equal or exceed ±42V, or if the lid is opened during such a measurement, the measurement will be aborted as if the STOP key had been pressed.

A switch inside the 16058A Test Fixture detects whether the fixture lid is open or closed. When the lid is closed, the switch connects the OPEN/CLOSE line of the system cable to ground, allowing the output voltage from any or all of the SMUs to exceed ±42V. When the lid is open, however, the OPEN/CLOSE line is open circuited, limitting output voltage to ±42V.

When the 4145A is used for an application that does not require the 16058 Test Fixture, the Shorting Connector (PN: 04145-61623, furnished with the 4145A) should be connected to the system cable connector on the 4145A's rear panel. The Shorting Connector grounds the OPEN/CLOSE to allow maximum output from the SMUs.

Note

The ±42V limit applies to both voltage source operation and I mode current source operation of the SMUs. For example, if the voltage compliance of an SMU operating in I mode is set at 50V, there is a possibility the output voltage will exceed 42V.

3-129. PLOT/PRINT Operations Using HP-IB Controller

3-130. When performing a PLOT or PRINT operation using an HP-IB controller, use the following procedure.

(1) Set the plotter or printer to "addressable."

(2) Interconnect the 4145A, HP-IB plotter or printer, and controller with HP-IB cables.

(3) Send the PLOT or PRINT command to the 4145A.

(4) Set the 4145A to TALKER and set plotter or printer to LISTENER.

(5) Set the ATN (Attention) Line to "Inactive" to start the plot or print operation. (REMOTE or RESUME command sets the ATN line "Inactive".)

(6) End of plot or print can be detected by monitoring the EOI Line or SRQ Line.

Note

If the controller attempts an HP-IB operation during a plot or print operation, an error may result or data may be incorrectly plotted or printed. Therefore, you cannot detect the end of a plot or print operation by reading the status byte of the 4145A.

Figure 3-49 shows programming examples of HP-IB controlled plot operations with the HP85 and HP9845 controllers.

Note

To execute the HP85 and HP9845 programs, the controller's I/O ROM and an HP-IB interface card are required.

HP85 (HP86/HP87) program

```
10 ON INTR 7 GOTO 70 ! Interrupt (PLOT END) handling  Instructions
20 ENABLE INTR 7;8 ! Enables controller to respond to an SRQ
30 OUTPUT 717 ;"PL100,100,5000,3000"
40 SEND 7 ; UNT UNL TALK 17 LISTEN 5 ! Asigns TALKER and LISTENER
50 RESUME 7 ! Sets ATN line to "Inactive"
60 GOTO 60
70 A=SPOLL(717)
80 IF BIT(A,2) THEN PRINT "END"
90 STATUS 7,1 ; B ! Reads and clears the interface register
100 BEEP
110 END
```

HP9826 (HP9836) program

```
10     CONTROL MASK 7;128!Permits interrupt only for an SRQ
20     ON INT #7 GOTO 80!Interrupt(PLOT END) handling instructions
30     CARD ENABLE 7!Enables controller to respond to an interrupt
40     OUTPUT 717;"PL100,100,5000,3000"
50     CONFIGURE 7 TALK = 17 LISTEN = 5
60     REMOTE 7!Sets ATN line to "Inactive"
70     GOTO 70
80     STATUS 717;A
90     IF BIT(A,2) THEN PRINT "END"
100    BEEP
110    END
```

HP9845 (HP9835) Program

```
10     ON INTR 7 GOTO 70 !Interrupt (PLOT END) handling instructions
20     ENABLE INTR 7;2 !Enables controller to respond an SRQ
30     OUTPUT 717;"PL100,100,5000,3000"
40     SEND 7;UNT UNL TALK 17 LISTEN 5 ! Asigns TALKER and LISTENER
50     REMOTE 7 !Sets ATN line to "Inactive"
60     GOTO 60
70     A=SPOLL(717)
80     IF BIT(A,2) THEN PRINT "END"
90     BEEP
100    END
```

Figure 3-49. Programs for HP-IB controlled PLOT Operations.

3-131. Measurement Ranges and Resolution

3-132. The 4145A measures dc voltage and current with (1) the voltage monitor function of each SMU, (2) the current monitor function of each SMU and (3) the voltage monitors (Vm). The measurement ranges and resolution for the SMUs and voltage monitors are shown in Figure 3-50.

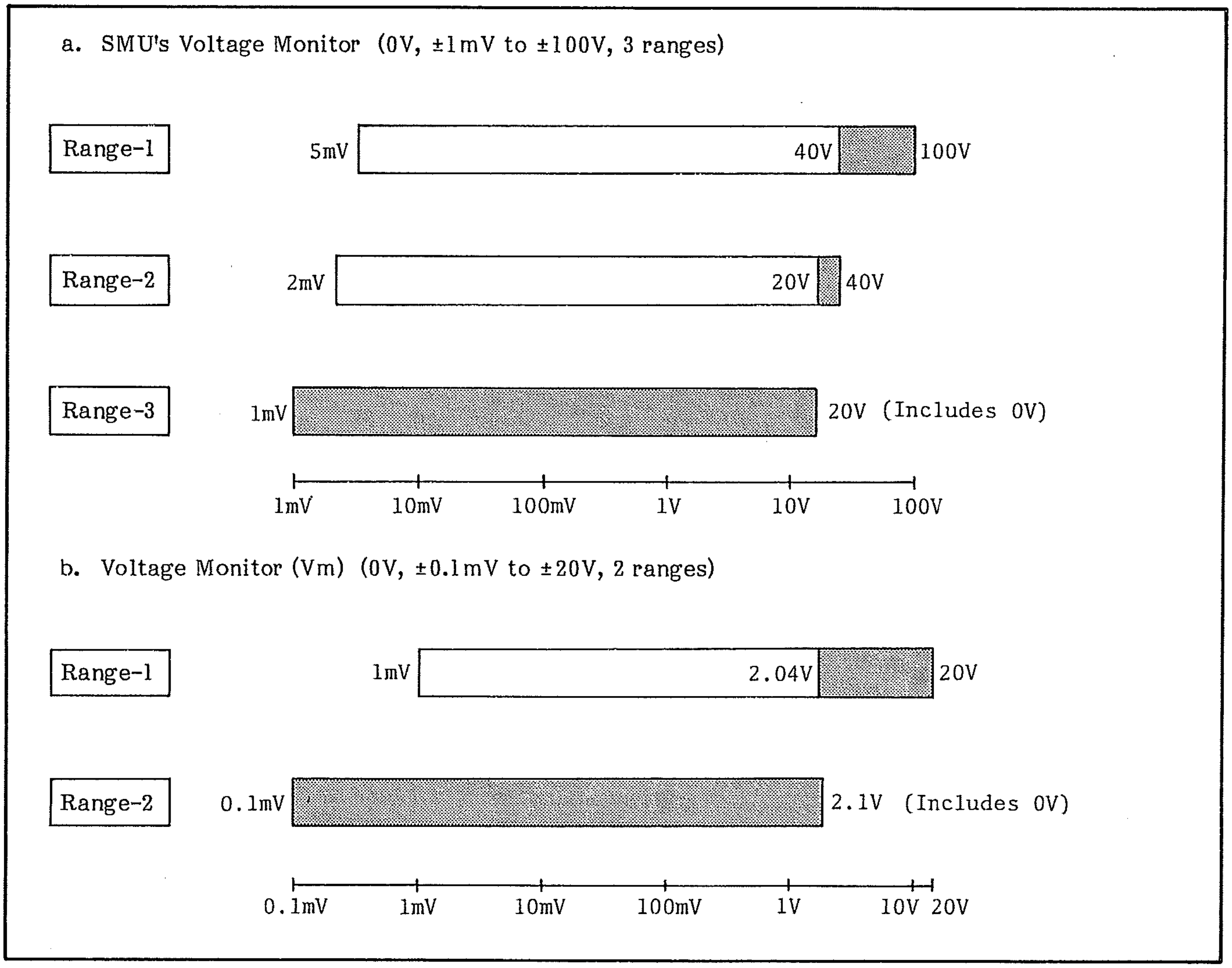
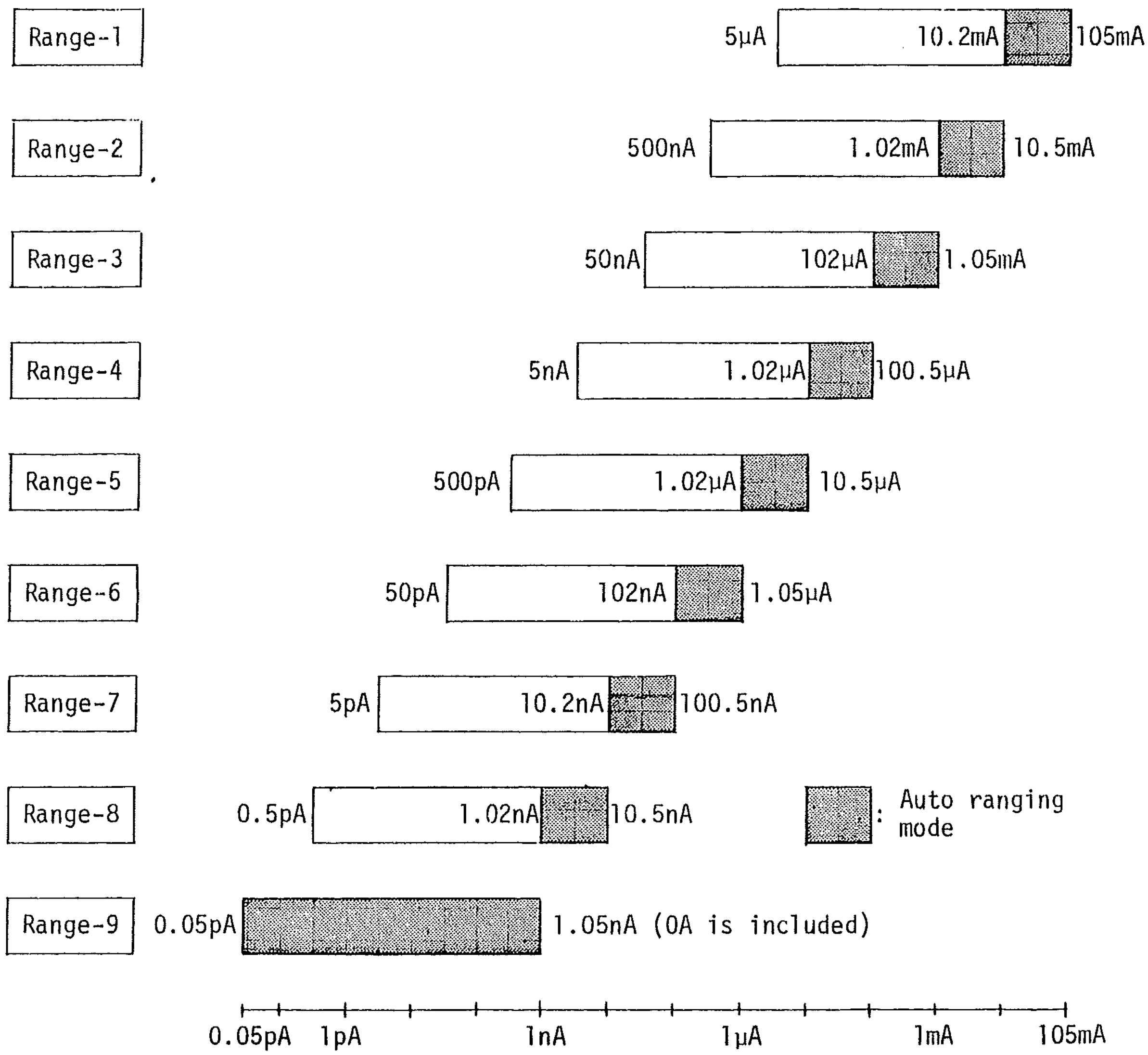


Figure 3-50. Measurement Ranges and Resolution.

c. SMU's Current Monitor (0A, ±0.05pA to ±105mA, 9 ranges)



Note: The maximum range in auto ranging mode is determined by the compliance setting.

Figure 3-50. Measurement Ranges and Resolution.

3-133. Resolution and Format for Displayed Data and Data Output.

3-134. Measurement results are stored as raw data. The 4145A then manipulates the stored raw data with (1) the user functions (i.e., to calculate HFE or GM) or (2) the analysis functions (Marker, Cursor, and Line).

Display resolution may differ depending on the measurement resolution because of the inherent errors of the digital data manipulations. The raw data are stored using a 3-byte 2's complement format (one byte has 8 bits; the first byte is for the exponent, the second and third bytes are for the mantissa). Therefore, the display resolution may be higher than that given in the specifications because of the conversion from 2's complement to decimal. The number of output/display digits and the display format are listed in Tables 3-13 and Figure 3-51.

Table 3-13. Number of Output/Display Digits

<table>
<tr><th rowspan="3">Output/Display Functions</th><th colspan="6">Display Digits and Format</th></tr>
<tr><th colspan="2">Voltage</th><th colspan="2">Current</th><th colspan="2">User Function</th></tr>
<tr><th>Digits</th><th>Format</th><th>Digits</th><th>Format</th><th>Digits</th><th>Format</th></tr>
<tr><td>Marker/Cursor in GRAPHICS Display</td><td rowspan="6">5</td><td rowspan="5">a</td><td rowspan="5">4</td><td rowspan="5">b</td><td rowspan="4">3</td><td rowspan="4">c</td></tr>
<tr><td>LIST Display</td></tr>
<tr><td>MATRIX Display</td></tr>
<tr><td>Cursor in SCHMOO Display</td></tr>
<tr><td>PRINT Function</td><td colspan="2" rowspan="3">not available</td></tr>
<tr><td>HP-IB Data Output</td><td>e</td><td>5</td><td>e</td></tr>
<tr><td>Keyboard Execution</td><td>4</td><td>d</td><td>4</td><td>d</td></tr>
<tr><td>Line in GRAPHICS Display</td><td colspan="6">3 Digits, Format: c</td></tr>
</table>

a. Voltage Display Format (5 digits, Min. = 0.1mV)

|V| < 10V	s n . n n n n V
10V ≤ |V| < 100V	s n n . n n n V
|V| = 100V	s n n n . n n V

s: Polarity (blank or "-")
n: Numeric (0 to 9)
.: Decimal point
V: Unit (volt)

b. Current Display Format (4 digits, Min. = 0.05pA)

All currnet values	s d d d d d u A

s: Polarity (blank or "-")
d: Numeric (0 to 9) or dicimal point
u: Engineering unit ("m", "μ", "n", or "p")
A: Unit (Ampere)

c. User Function Display Format (3 digits)

1.00 ≤ |Mantissa| < 99.9	s d d d n E ± mm
100 ≤ |Mantissa| < 999	s n n n E ± mm

s: Polarity (blank or "-")
d: Numeric ("0" to "9") or decimal point
n: Numeric ("0" to "9")
E: Exponent
±mm: 2-digit exponent(Engineering notation, multiples of 3, from -39 to +36)

d. Display Format for Keyboard-Executed Calculations

All variable values	s d d d d n E ± mm

Designations are the same as those of format c.

e. HP-IB Data Output Format (5 digits)

All variable values	s n d d d n n E ± mm

Designations are the same as those of format c.

Figure 3-51. Display/Output Format.

Table 4-1. Recommended Test Equipment

Equipment	Critical Specifications	Recommended Model	Use*[1]
Digital DC Voltmeter	Voltage range : 100mV to 200V f.s. Sensitivity : 100μV Accuracy : 0.002% Input impedance: > 10MΩ	HP 3455A	P, A, T
Oscilloscope	Band width : > 10MHz Vertical Sensitivity: 0.001 Volt/DIV Channel : dual	HP 1740A*[2]	P, A, T
RC Box	Range : $10^2\Omega$ - $10^{11}\Omega$ Accuracy: 0.1% - 1% Furnished accessories: (1) Triaxial (Male)-to-Triaxial (Male) Cable (HP P/N: 16053-61002) (2) BNC (Male)-to-BNC (Male) Cable (HP P/N: 16053-61003) (3) Triaxial (Male)-BNC (Female) Adapter (HP P/N: 1250-0595) (4) BNC T Type Adapter (HP P/N: 1250-0781)	HP 16340A	P
Desktop Computer	For HP-IB controller	HP 9825B	P
HP-IB Interface Card with cable		HP 98034B	P
I/O ROMs		HP 98210A HP 98213A	P
Test Fixture with Furnished Accessories		HP 16058A	P, A
Cables	Alligator Clips-to-Dual Banana Plug Test Lead	HP 11002A	P, A, T
	Probe and Alligator Clip-to-Dual Banana Test Lead	HP 11003A	
	BNC (Male)-to-BNC (Male), 61cm	HP 11170B	
	BNC (Male)-to-Dual Banana Plug Test Lead	HP 11001A	
	BNC (Male)-to-BNC (Male), 23cm	HP 10502A	

*[1]: P = Performance Test, A = Adjustment, T = Troubleshooting

*[2]: The waveforms shown in Section V were obtained with the 1741A.

Table 4-1. Recommended Test Equipment (Cont'd)

Equipment	Critical Specifications	Recommended Model	Use*[1]
Probes	10:1 Divider Probe Input impedance: 10MΩ	HP 10004A	A, T
	1:1 Probe	HP 10007B	
4145A Product Support Package	Tools included: (1) CE Disc (HP P/N: 04145-65101) (2) Blank Disc (HP P/N: 04145-65102) (3) Eccentric Rod (HP P/N: 04145-65103) (4) Tension Gauge (HP P/N: 04145-65104) (5) SMU Test Adapter (HP P/N: 04145-65001) (6) Shorting Terminator (HP P/N: 04145-65002) (7) Extender Board (24-pin Single) (HP P/N: 04145-66520) (8) Extender Board (24-pin Dual) (HP P/N: 04145-66521) (9) Cleaning Disc (HP P/N: 9164-0168) (10) Disc Case (HP P/N: 1540-0773)	HP P/N 04145-65100	P, A, T
Shorting Connector		HP P/N 04145-61623	P
Signature Analyzer		HP 5004A	T

SECTION IV
PERFORMANCE TESTS

4-1. INTRODUCTION

4-2. This section describes the tests and procedures used to verify the instrument specifications listed in Table 1-1. All tests can be performed without access to the interior of the instrument. A simpler, automatic operational test is presented in Section III under Self Test (paragraph 3-10). The performance tests described here can also be used to perform incoming inspection of the instrument and to verify that the instrument meets specified performance after troubleshooting and/or adjustment. If the performance tests indicate that the instrument is operating outside specified limits, check that the controls on the instruments used in the test and the test set-up itself are correct, then proceed with adjustments and/or troubleshooting.

Note

1. To ensure proper test results and instrument operation, Hewlett-Packard suggest a 40 minute warm-up and stabilization period before performing any of the performance tests.

2. Initial control settings described in paragraph 3-14 must be used for each performance test. Exceptions to these settings will be noted as they occur. After completing a performance test, return 4145A controls to the initial control settings.

4-3. EQUIPMENT REQUIRED

4-4. Equipment required for performance tests is listed in Table 4-1. Any equipment that satisfies the critical specifications given in the table may be substituted for the recommended model(s).

Note

Equipment should be calibrated by an instrument traceable to NBS or an equivalent standards; or calibrated directly by an authorized calibration organization such as NBS. The calibration cycle should be in accordance with stability specifications of each component.

4-5. TEST RECORD

4-6. Performance test results can be recorded on the Test Record at the completion of the test. The Test Record is at the end of this section. It lists all test specifications and acceptable limits. The results recorded at incoming inspection can be used for comparison in periodic maintenance, troubleshooting, and after repairs or adjustments.

4-7. CALIBRATION CYCLE

4-8. This instrument requires periodic verification of performance. Depending on the conditions under which the instrument is used, e.g., environmental conditions or frequency of use, the instrument should be checked with the performance tests described here, at least once a year. To keep instrument down-time to a minimum and to insure optimum operation, preventive maintenance should be performed at least twice a year.

4-9. GRAPHICS DISPLAY UNIT INTENSITY AND FOCUS CHECK

PURPOSE: This check visually verifies that the writing beam of the Graphics Display Unit (GDU) has the correct intensity and is properly focused.

PROCEDURE:

1. Turn on the 4145A, then display the DIAGNOSTICS page by pressing the DIAG softkey.

2. Display the test pattern for the GDU as shown in Figure 4-1 by pressing the G.D. TEST softkey.

3. Verify that the brightness of the writing beam for lines 1, 2, 3, and 4 is as described below:

   line 1 : full brightness
   line 2 : dim
   line 3 : half brightness
   line 4 : second brightness

4. Verify that the writing beam is properly focused for sharp, well-defined trace at points A, B, C, and D, and over the entire CRT display.

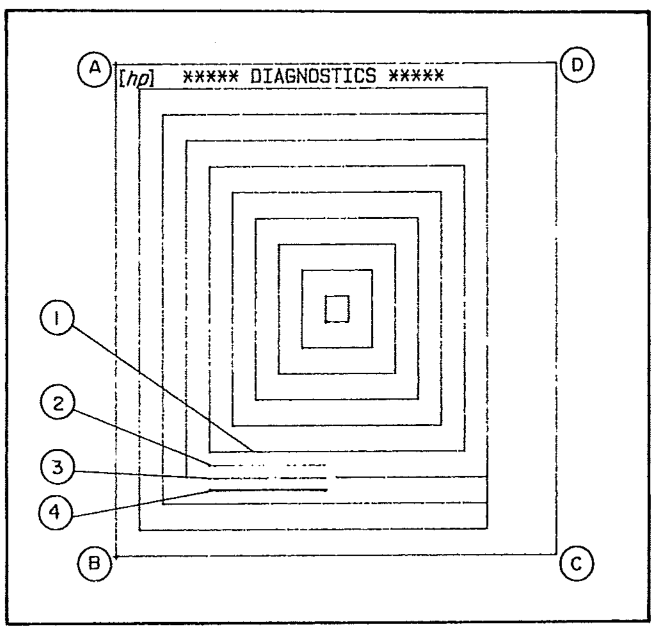


Figure 4-1. Test Pattern for GDU.

PERFORMANCE TESTS

Note

If intensity and focus of the writing beam need adjustment, perform Graphic Display Unit Intensity and Focus Adjustment in Section V of this manual. If any trace distortion is observed, perform performance tests and adjustments in Section IV and V of the 1345A's Operating and Service Manual, located at the back of this binder.

Note

When the procedures in Section IV and V of the 1345A's manual are performed, the connector on the A1 GDU Control Board must be disconnected. Refer to Figure 4-2 for its location.

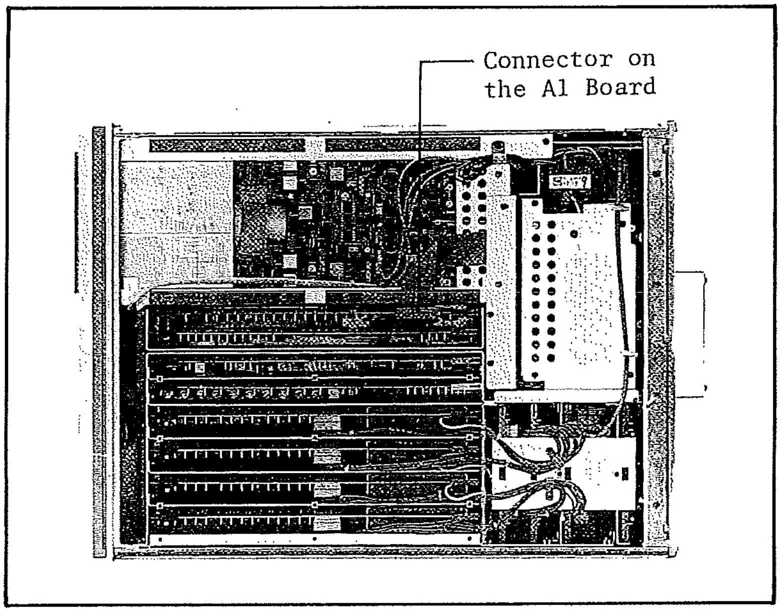


Figure 4-2. GDU Connector Location.

4-10. PAGE AND KEY FUNCTION CHECK

PURPOSE: This check verifies that the thirteen pages, including MENU, CHANNEL DEFINITION, DIAGNOSTICS, and so on, can be displayed without error codes or error messages. Also, this check verifies that the sixty-six keys function properly.

PROCEDURE:

1. Insert one of the discs (software discs furnished with the 4145A) into the flexible-disc drive, then turn on the 4145A.

2. Verify that each of the thirteen pages is displayed without any error codes or error messages, by pressing the MENU key, PREV key, NEXT key, and softkeys. Refer to Section III of this manual for details on page control.

3. Repeat step 2 for the rest of the discs.

4. Display the MENU page, then display the DIAGNOSTICS page by pressing the DIAG softkey.

5. Obtain the display shown Figure 4-3 by pressing the F.P. TEST softkey.

6. Check that the LED indicator lamps and sixty-six keys function properly as described in Figure 3-32 in Section III of this manual.

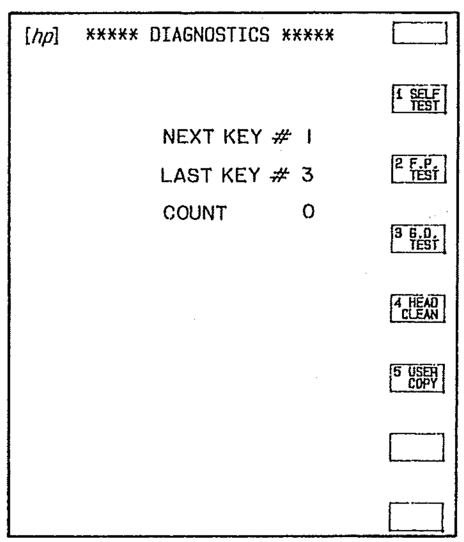


Figure 4-3. Display for Key Function Check.

PERFORMANCE TESTS

4-11. SMU ACCURACY TEST

DESCRIPTION :

The SMU Accuracy Test consists of four tests :

(1) Voltage Control Accuracy Test

(2) Voltage Measurement Accuracy Test

(3) Current Measurement Accuracy Test

(4) Current Control Accuracy Test

(1) VOLTAGE CONTROL ACCURACY TEST

PURPOSE : This test verifies that the specified output voltage is correctly output from each SMU channel.

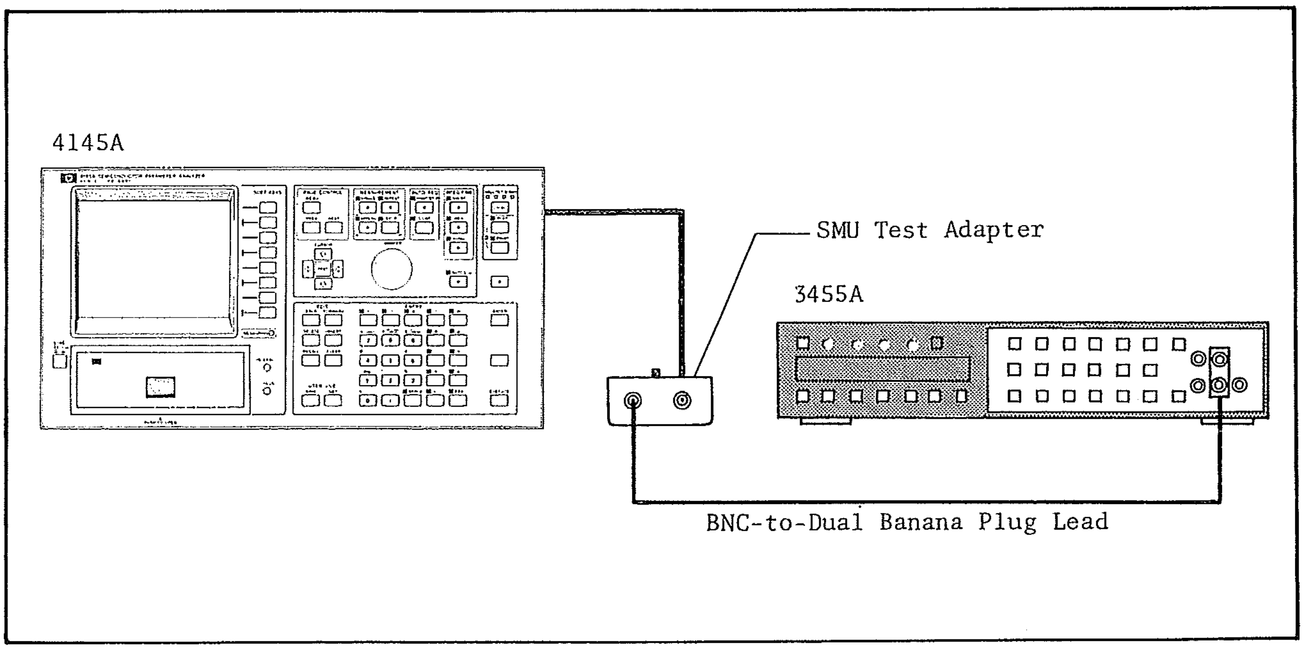


Figure 4-4. Voltage Control Accuracy Test Setup.

EQUIPMENT:

DVM .... HP MODEL 3455A*
SMU Test Adapter .... HP P/N 04145-65001
BNC (Male)-to-Dual Banana Plug Test Lead .... HP MODEL 11001A
Shorting Connector .... HP P/N 04145-61623

* The 3455A must be calibrated before testing.

PROCEDURE:

1. Connect the adapter (HP P/N : 04145-65001) to the 4145A's SMU channel 1 connector on the rear panel.

2. Connect the shorting connector to the 24 pin connector (labeled "TO 16058A TEST FIXTURE") on the rear panel.

3. Connect the 3455A to the adapter's BNC connector and set the adapter's SELECTOR switch to Vo.

4. Set the 3455A's controls* as follows :

   FUNCTION .... ⎓V
   RANGE .... AUTO
   TRIGGER .... INTERNAL
   MATH .... OFF
   AUTO CAL .... OFF
   HIGH RESOLUTION .... ON

   * This setting is the same for all SMU accuracy tests.

5. Set the 4145A's controls as follows :

[hp] *** CHANNEL DEFINITION ***

	NAME		SOURCE	
CHAN	V	I	MODE	FCTN
SMU1	V1		V	VAR1
SMU2				
SMU3				
SMU4				
Vs 1		-----	V	
Vs 2		-----	V	
Vm 1	VM	-----	----	----
Vm 2		-----	----	----

USER FCTN	NAME (UNIT) = EXPRESSION
1	VO (V) = V1
2	( ) =

Figure 4-5. Measurement Setup.

i) On the CHANNEL DEFINITION page :

Set up the page as shown in Figure 4-5. To define SMU1, press the NOT USE softkey to delete the line, then assign V name, SOURCE MODE, and SOURCE FCTN. VM is used as a dummy to display V1's output after measurement.

[hp] ****** SOURCE SET UP ******

	VAR1	VAR2
NAME	V1	
SWEEP MODE	LINEAR	LINEAR
START	.0000V	
STOP	20.000V	-------
STEP	20.000V	
NO. OF STEP	2	
COMPLIANCE	100.0mA	

CONSTANT	SOURCE	COMPLIANCE

5.000 Delay Time (5s)

[hp] ** MEAS & DISP MODE SET UP **

MEASUREMENT MODE: SWEEP

DISPLAY MODE: LIST

NAMES	~~V0~~ Dn worry
	VM

Figure 4-5. Measurement Setup (Cont'd).

ii) On the SOURCE SET UP page :

Set the source channel parameters as shown in Figure 4-5. Set HOLD TIME and DELAY TIME to 0 seconds and 5 seconds, respectively.

iii) On the MEAS & DISP MODE SET UP page :

Select LIST as the display mode for the measurement results.

iv) INTEG TIME .... LONG [illegible]

6. Perform measurement by pressing the REPEAT key.

7. Record the readings on the 3455A for the start voltage (0 volts) and stop voltage (20 volts) when they are output, then verify that the recorded readings satisfy the test limits listed in Table 4-3.

8. Press the STOP key to end measurement.

9. Repeat steps 5 through 8 for each Source Setup listed in Table 4-2. The source parameters--START, STOP, and STEP--on the SOURCE SET UP page in step 4 must be changed as listed in the table.

10. Repeat steps 5 through 9 for SMU channels 2, 3, and 4.

Table 4-2. Source Parameter Changes

	Source Setup (xxx Volts to xxx volts)				
Source Parameters	-20 to -20	0 to 40	-40 to -40	0 to 100	-100 to -100
START	-20.000V	.0000V	-40.000V	.0000V	-100.00V
STOP	-20.000V	40.000V	-40.000V	100.00V	-100.00V
STEP	20.000V	40.000V	40.000V	100.00V	100.00V
DELAY TIME	0 s	5 s	0 s	5 s	0 s

Table 4-3. Test Limits for Voltage Control Accuracy Test

Range of SMU Channel Tested	Voltage Sweep (xxx volts to xxx volts)	Output Voltage from SMU (Volt)	Test Limit
20 volt	0 to 20	.0000	0 volts ± 0.01 volts
		20.000	20 volts ± 0.03 volts
	-20 to -20	-20.000	-20 volts ± 0.03 volts
40 volt	0 to 40	.0000	0 volts ± 0.02 volts
		40.000	40 volts ± 0.06 volts
	-40 to -40	-40.000	-40 volts ± 0.06 volts
100 volt	0 to 100	.0000	0 volts ± 0.05 volts
		100.00	100 volts ± 0.15 volts
	-100 to -100	-100.00	-100 volts ± 0.15 volts

(2) VOLTAGE MEASUREMENT ACCURACY TEST

PURPOSE: This test verifies that the SMU accurately performs voltage measurements.

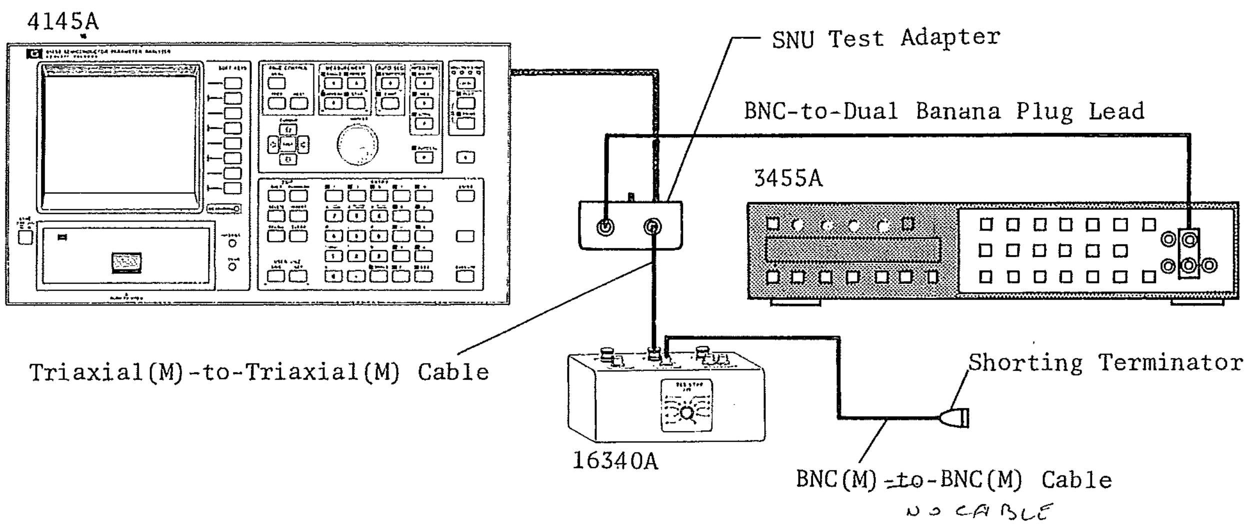


Figure 4-6. Voltage Measurement Accuracy Test Setup.*

* This setup is the same as for the Current Measurement Test and Current Control Accuracy Test.

EQUIPMENT:

DVM	HP MODEL 3455A
RC Box	HP MODEL 16340A
SMU Test Adapter	HP P/N 04145-65001
BNC (Male)-to-Dual Banana Plug Test Lead	HP MODEL 11001A
Triaxial (Male)-to-Triaxial (Male) Cable	HP P/N 16053-61002*
BNC (Male)-to-BNC (Male) Cable	HP P/N 16053-61003*
Shorting Connector	HP P/N 04145-61623
Shorting Terminator	HP P/N 04145-65002

* furnished with the 16340A

PROCEDURE :

1. Connect the adapter (HP P/N : 04145-65001) to the 4145A's SMU channel 1 connector on the rear panel.

2. Connect the 3455A and the 16340A's female triaxial connector (for the $10^2\Omega$ - $10^{10}\Omega$ range) to the female BNC connector (labeled "MONITOR") and the female triaxial connector (labeled "TO 16340A") of the adapter, respectively. Use BNC (male)-to-dual banana test lead and triaxial (male)-to-triaxial (male) cable.

3. Connect the BNC-to-BNC cable (furnished with the 16340A) to the female BNC connector (for the $10^2\Omega$-$10^{10}\Omega$ range), then terminate the cable with the shorting terminator.

4. Connect the shorting connector to the 24 pin connector (labeled "TO 16058A TEST FIXTURE") on the rear panel.

5. Set the adapter's SELECTOR switch to V_G, then set the 16340A's range to $10^8\Omega$.

6. Set the 3455A's controls as described in step ~~3~~ 4 of the Voltage Control Accuracy Test.

7. Set the 4145A's controls as follows :

[hp] *** CHANNEL DEFINITION ***

	NAME		SOURCE	
CHAN	V	I	MODE	FCTN
SMU1	V1	I1	I	VAR1
SMU2				
SMU3				
SMU4				
Vs 1		-----	V	
Vs 2		-----	V	
Vm 1		-----	----	----
Vm 2		-----	----	----

USER FCTN	NAME (UNIT) = EXPRESSION
1	____( )=
2	____( )=

Figure 4-7. Measurement Setup.

i) On the CHANNEL DEFINITION page :

Set up the page as shown in Figure 4-7.

ii) On the SOURCE SET UP page :

Set up the page as shown in Figure 4-7.

iii) On the MEAS & DISP MODE SET UP page :

Select LIST as the display mode for measurement results.

[hp] ****** SOURCE SET UP ******

	VAR1	VAR2
NAME	I1	
SWEEP MODE	LINEAR	LINEAR
START	150.0nA	
STOP	150.0nA	-------
STEP	150.0nA	
NO. OF STEP	1	
COMPLIANCE	20.000V	

CONSTANT	SOURCE	COMPLIANCE

[hp] ** MEAS & DISP MODE SET UP **

MEASUREMENT MODE: SWEEP

DISPLAY MODE: LIST

NAMES	V1

Figure 4-7. Measurement Setup (Cont'd).

8. Perform the first measurement for the SMU's 20 volt range by pressing the REPEAT key.

9. Record the readings on the 4145A for the monitored voltage value V1a and on the 3455A for Va, then end measurement by pressing the STOP key.

10. Change the source parameters--START and STOP--to -150.0nA on the SOURCE SET UP page for the second measurement.

11. Perform the second measurement by pressing the REPEAT key.

12. Record the readings on the 4145A for the monitored voltage value V1b and on the 3455A for Vb, then end measurement by pressing the STOP key.

13. Verify that the error and offset defined by the following equations satisfy the test limit listed in Table 4-5.

$$\text{error} = \frac{V1a - V1b}{Va - Vb} - 1$$

$$\text{offset} = (V1a) - ((1 + \text{error}) * Va)$$

14. Repeat steps 7 through 13 for the 40 volt range and 100 volt range. The source parameters--START, STOP, STEP, and COMPLIANCE--on the SOURCE SET UP page must be changed as listed in Table 4-4.

15. Repeat steps 7 through 14 for SMU channels 2, 3, and 4.

Table 4-4. Source Parameter Changes

	SMU Range Tested	40 volt		100 volt	
	Measurement	1st	2nd	1st	2nd
Source Parameter	START	350.0nA	-350.0nA	900.0nA	-900.0nA
	STOP	350.0nA	-350.0nA	900.0nA	-900.0nA
	STEP	350.0nA	350.0nA	900.0nA	900.0nA
	COMPLIANCE	40.000V	40.000V	100.00V	100.00V

Table 4-5. Test Limits for Voltage Measurement Accuracy Test

SMU Range Tested	20 volt	40 volt	100 volt
Error (%)	±0.1	±0.1	±0.1
Offset	±10mV	±20mV	±50mV

(3) CURRENT MEASUREMENT ACCURACY TEST

PURPOSE: This test verifies that the SMU accurately performs current measurements.

EQUIPMENT:

The equipment required is the same as that for the Voltage Measurement Accuracy Test.

PROCEDURE:

1. Perform steps 1 through 6 of the Voltage Measurement Accuracy Test described on pages 4-9 to 4-12.

2. Set the adapter's SELECTOR switch to V_0, and the 16340A's range to $10^2 \Omega$.

[hp] *** CHANNEL DEFINITION ***

	NAME		SOURCE	
CHAN	V	I	MODE	FCTN
SMU1	V1	I1	V	VAR1
SMU2				
SMU3				
SMU4				
Vs 1		------	V	
Vs 2		------	V	
Vm 1		------	-----	-----
Vm 2		------	-----	-----

USER FCTN	NAME (UNIT) = EXPRESSION
1	____( )=
2	____( )=

[hp] ****** SOURCE SET UP ******

	VAR1	VAR2
NAME	V1	
SWEEP MODE	LINEAR	LINEAR
START	9.1000V	
STOP	9.1000V	-------
STEP	9.1000V	
NO. OF STEP	1	
COMPLIANCE	100.0mA	

CONSTANT	SOURCE	COMPLIANCE

Figure 4-8. Measurement Setup.

3. Set the 3455A's controls as described in step 3 of the Voltage Control Accuracy Test.

4. Set the 4145A's controls as follows:

   i) On the CHANNEL DEFINITION page:

   Set up the page as shown in Figure 4-9.

   ii) On the SOURCE SET UP page:

   Set up the page as shown in Figure 4-9.

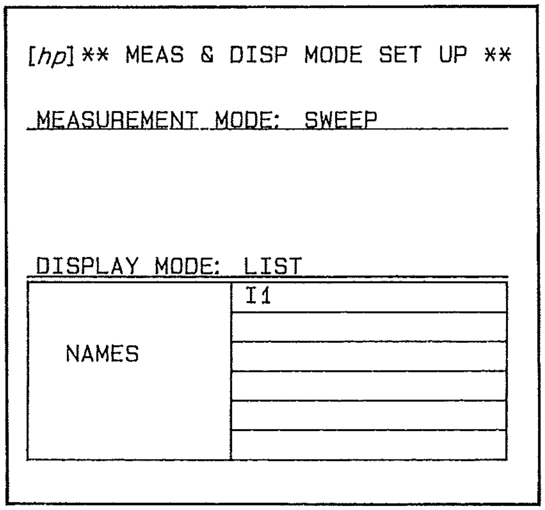


Figure 4-8. Measurement Setup (Cont'd).

iii) On the MEAS & DISP MODE SET UP page:

Select LIST as the display mode for the measurement results.

iv) INTEG TIME .... LONG

5. Perform measurement by pressing the REPEAT key.

6. Record the readings on the 4145A for monitored current value Ila and on the 3455A for Va.

7. End measurement by pressing the STOP key.

8. Change the source parameters--START, STOP, and STEP—on the SOURCE SET UP page to -9.1000V, then perform measurement by pressing the REPEAT key.

9. Record the readings on the 4145A for monitored current value Ilb and on the 3455A for Vb, then end measurement by pressing the STOP key.

10. Verify that the error and offset defined by the following equations satisfy the test limits listed in Table 4-7.

$$\text{error} = \frac{Ila - Ilb}{\frac{Va - Vb}{R}} - 1$$

R: Calibrated value of the 16340A's resistor

$$\text{offset} = Ila - (1+\text{error}) * \frac{Va}{R}$$

11. Repeat steps 2 through 8 for ranges $10^3\,\Omega$ through $10^9\,\Omega$. The required source parameter and adaptor SELECTOR switch position must be changed as listed in Table 4-6.

12. Repeat steps 2 through 9 for SMU channels 2, 3, and 4.

Table 4-6. Source Parameter Changes

	16340A's Range								
Source Parameter	$10^3\Omega$	$10^4\Omega$	$10^5\Omega$	$10^6\Omega$	$10^7\Omega$	$10^8\Omega$	$10^9\Omega$	$10^9\ \Omega$	
START	—	—	—	—	—	—	—	.91	-.91
STOP	—	—	—	—	—	—	—	.91	-.91
STEP	—	—	—	—	—	—	—	.91	-.91
COMPLIANCE	10.00mA	1.000mA	100.0µA	10.00µA	1.000µA	100.0nA	10.00nA	1.000nA	
Selector Switch Position	V_O			V_G					

Table 4-7. Test Limits for Current Measurement Accuracy Test

16340A's Range	$10^2\Omega$	$10^3\Omega$	$10^4\Omega$	$10^5\Omega$	$10^6\Omega$	$10^7\Omega$	$10^8\Omega$	$10^9\Omega$	$10^9\Omega$
Error (%)	±0.3	±0.3	±0.3	±0.3	±0.3	±0.5	±0.5	±1	±1
Offset	±0.12mA	±12µA	±1.2µA	±0.12µA	±12nA	±1.2nA	±0.12nA	±17pA	±6.2pA

(4) CURRENT CONTROL ACCURACY TEST

PURPOSE: This test verifies that the specified output current is correctly output from each SMU channel.

EQUIPMENT:

Same as that for the Voltage Measurement Accuracy Test.

PROCEDURE:

1. Perform steps 1 through 4 of the Voltage Measurement Accuracy Test described on pages 4-9 to 4-12.

2. Set the adapter's SELECTOR switch to V_o, and the 16340A's range to $10^2\Omega$.

3. Set the 3455A's controls as described in step 3 of the Voltage Control Accuracy Test.

4. Set the 4145A's controls as follows:

   i) On the CHANNEL DEFINITION page:

   Set up the page as shown in Figure 4-9.

   ii) On the SOURCE SET UP page:

   Set up the page as shown in Figure 4-9.

ii) On the SOURCE SET UP page:

Set up the page as shown in Figure 4-9.

[hp] *** CHANNEL DEFINITION ***

	NAME		SOURCE	
CHAN	V	I	MODE	FCTN
SMU1	V1	I1	I	VAR1
SMU2				
SMU3				
SMU4				
Vs 1		------	V	
Vs 2		------	V	
Vm 1		------	----	----
Vm 2		------	----	----

USER FCTN	NAME (UNIT) = EXPRESSION
1	____( )=
2	____( )=

[hp] ****** SOURCE SET UP ******

	VAR1	VAR2
NAME	I1	
SWEEP MODE	LINEAR	LINEAR
START	91.00mA	
STOP	91.00mA	-------
STEP	91.00mA	
NO. OF STEP	1	
COMPLIANCE	10.000V	

CONSTANT	SOURCE	COMPLIANCE

Figure 4-9. Measurement Setup.

[hp] ** MEAS & DISP MODE SET UP **

MEASUREMENT MODE: SWEEP

DISPLAY MODE: LIST

NAMES	V1

Figure 4-9. Measurement Setup (Cont'd).

iii) On the MEAS & DISP MODE SET UP page:

Select LIST as the display mode for the measurement results.

iv) INTEG TIME .... LONG

5. Perform the first measurement by pressing the REPEAT key.

6. Record the reading on the 3455A for Va.

7. End the measurement by pressing the STOP key.

8. Change the source parameters--START, STOP, and STEP--on the SOURCE SET UP page to 11mA, then perform the second measurement by pressing the REPEAT key.

9. Record the reading on the 3455A for Vb, then end measurement by pressing the STOP key.

10. Verify that the error and offset defined by the following equations satisfy the test limits listed in Table 4-9.

$$\text{error} = \frac{\frac{Va - Vb}{R}}{I1 - I2} - 1$$

$$\text{offset} = \frac{Va}{R} - (1+\text{error}) * I1$$

R: Calibrated value of the 16340A's resistor

I1, I2: START values set on the SOURCE SET UP page for the measurements of Va and Vb.

11. Repeat steps 2 through 8 for ranges $10^2\Omega$ and $10^3\Omega$. The source parameters must be changed as described in Table 4-8.

12. Repeat steps 2 through 9 for SMU channels 2, 3, and 4.

PERFORMANCE TESTS

Table 4-8. Source Parameter Changes

<table>
<tr><th rowspan="2">16340A's Range</th><th rowspan="2">Meas.
(Measurement)</th><th colspan="4">Source Parameter</th></tr>
<tr><th>START</th><th>STOP</th><th>STEP</th><th>COMPLIANCE</th></tr>
<tr><td rowspan="2">$10^2\Omega$</td><td>1st</td><td colspan="2">-91.000mA</td><td>91.000mA</td><td rowspan="6">10.000V</td></tr>
<tr><td>2nd</td><td colspan="2">-11.000mA</td><td>11.000mA</td></tr>
<tr><td rowspan="4">$10^3\Omega$</td><td>1st</td><td colspan="2">9.1000mA</td><td>9.1000mA</td></tr>
<tr><td>2nd</td><td colspan="2">1.1000mA</td><td>1.1000mA</td></tr>
<tr><td>1st</td><td colspan="2">-9.1000mA</td><td>9.1000mA</td></tr>
<tr><td>2nd</td><td colspan="2">-1.1000mA</td><td>1.1000mA</td></tr>
</table>

Table 4-9. Test Limits for Current Control Accuracy Test

16340A's Range	$10^2\Omega$	$10^3\Omega$
Error (%)	±0.3	±0.3
Offset	±0.12mA	±12μA

4-12. VS ACCURACY TEST

PURPOSE: This test verifies that the specified output voltage is correctly output from each VS (Voltage Source) channel.

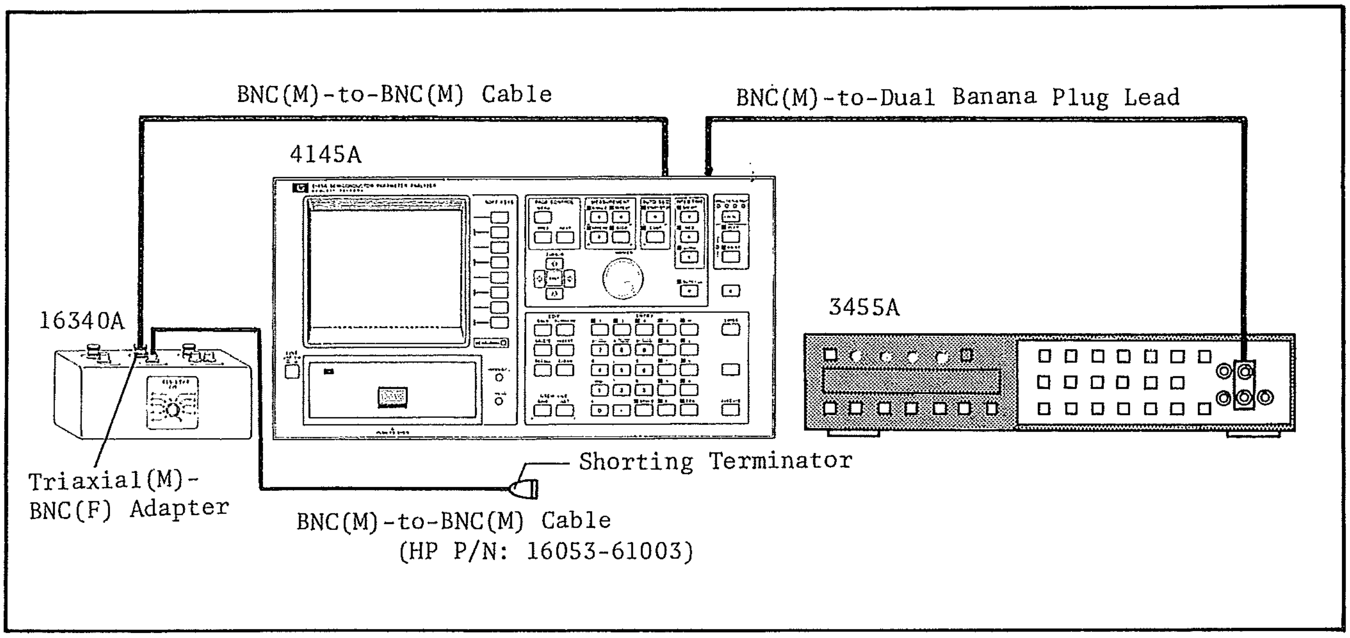


Figure 4-10. VS Accuracy Test Setup.

EQUIPMENT:

DVM	HP MODEL 3455A
RC Box	HP MODEL 16340A
BNC (Male)-to-Dual Banana Plug Test Lead	HP MODEL 11001A
BNC (Male)-to-BNC (Male) Cable	HP P/N 16053-61003*
Triaxial (Male)-BNC (Female) Adapter	HP P/N 1250-0595*
BNC T Type Adapter	HP P/N 1250-0781*
BNC (Male)-to-BNC (Male) Cable	HP P/N 11170B
Shorting Terminator	HP P/N 04145-65002

* furnished with the 16340A

PROCEDURE:

1. Connect the triaxial (male)-BNC (female) adapter and BNC (male)-to-BNC (male) cable (HP P/N: 16053-61003) to the 16340A's female triaxial connector and female BNC connector for ranges $10^2\Omega$ to $10^{10}\Omega$, respectively.

2. Terminate the BNC cable with the shorting terminator. See Figure 4-10.

3. Connect the BNC T type adapter to VS channel 1 (Vs1), then connect the 3455A and the 16340A to the VS channel 1 (Vs1) as shown in Figure 4-10.

4. Set the 16340A's range to $10^4\,\Omega$.

5. Set the 3455A's controls as follows :

FUNCTION .... ═V
RANGE .... AUTO
TRIGGER .... INTERNAL
MATH .... OFF
AUTO CAL .... OFF
HIGH RESOLUTION .... ON

6. Set the 4145A's controls as follows :

[hp] *** CHANNEL DEFINITION ***

CHAN	NAME V	NAME I	SOURCE MODE	SOURCE FCTN
SMU1				
SMU2				
SMU3				
SMU4				
Vs 1	VS1	-----	V	CONST
Vs 2		-----	V	
Vm 1	VM1	-----	----	----
Vm 2		-----	----	----

USER FCTN	NAME (UNIT) = EXPRESSION
1	____( )=
2	____( )=

[hp] ****** SOURCE SET UP ******

	VAR1	VAR2
NAME		
SWEEP MODE		LINEAR
START		
STOP		-------
STEP		
NO. OF STEP		
COMPLIANCE		

CONSTANT	SOURCE	COMPLIANCE
VS1 V	.0000V	--------

Figure 4-11. Measurement Setup.

i) On the CHANNEL DEFINITION page:

Set up the page as shown in Figure 4-11. VM1 is used as a dummy to display Vs1's output after measurement.

ii) On the SOURCE SET UP page :

Set up the page as shown in Figure 4-11.

[hp] ** MEAS & DISP MODE SET UP **

MEASUREMENT MODE: TIME DOMAIN

WAIT TIME	.00s
INTERVAL	.01s
NO. OF RDNGS	1

DISPLAY MODE: LIST

NAMES	VM1

Figure 4-11. Measurement Setup (Cont'd).

iii) On the MEAS & DISP MODE SET UP page :

Select LIST as the display mode for measurement results.

7. Perform measurement by pressing the REPEAT key.

8. Record the reading on the 3455A, then verify that the reading satisfies the test limit listed in Table 4-10.

9. End the measurement by pressing the STOP key.

10. Repeat steps 6 through 9 for VS's outputs 20 volts and -20 volts.

11. Repeat steps 6 through 10 for VS channel 2.

Table 4-10. Test Limits for VS Accuracy Test

VS Output (volt)	0	20	-20
Test Limit	0V ± 0.01V	20V ± 0.11V	-20V ± 0.11V

4-13. VM ACCURACY TEST

PURPOSE: This test verifies that each of VM (Voltage Monitor) channels (Vm1 and Vm2) accurately perform voltage monitoring.

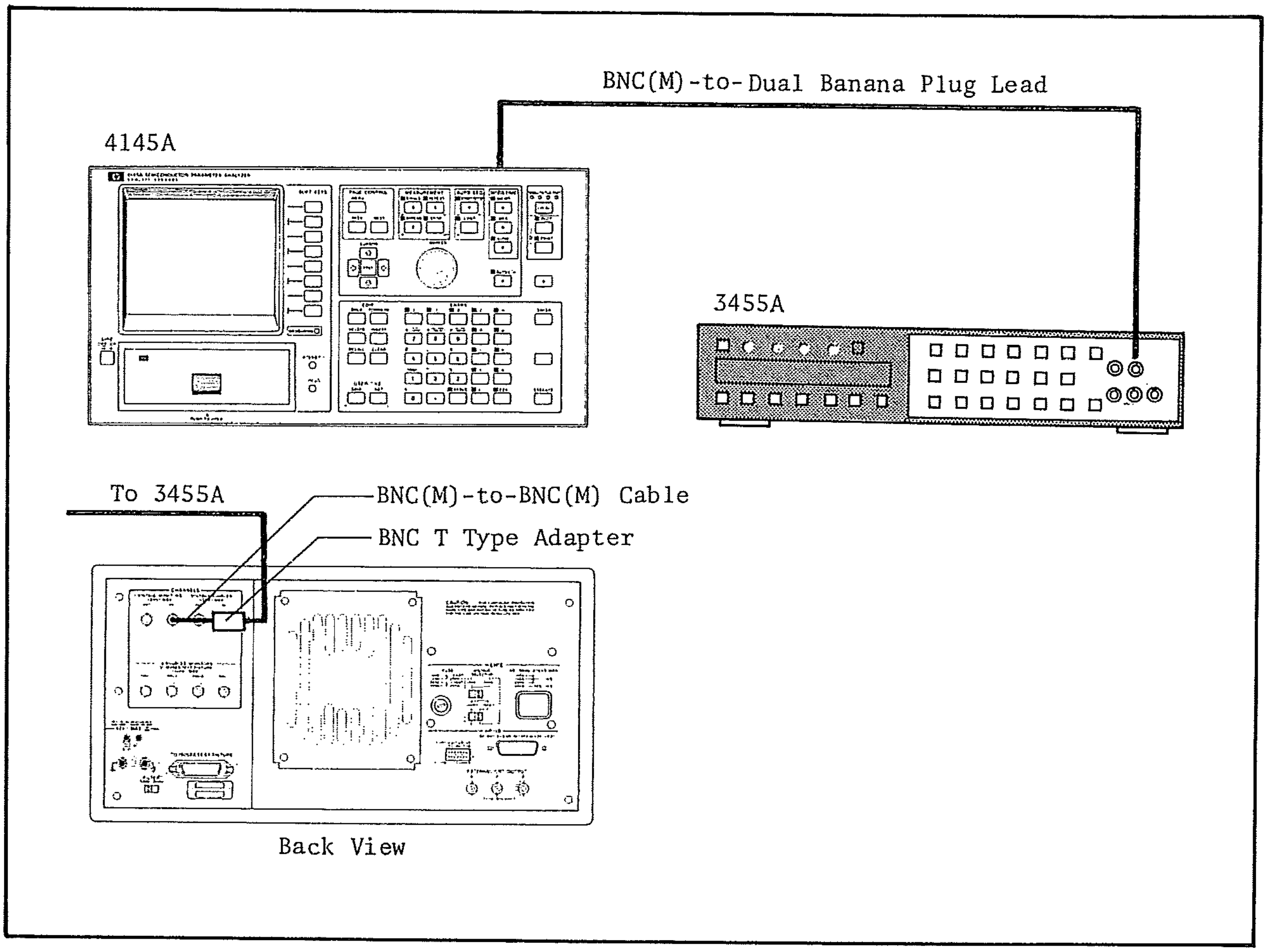


Figure 4-12. MU Accuracy Test Setup.

EQUIPMENT:

DVM	HP MODEL 3455A
BNC (male)-to-Dual Banana Plug Test Lead	HP MODEL 11001A
BNC (Male)-to-BNC (Male) Cable	HP MODEL 10502A
BNC T Type Adapter	HP P/N 1250-0781

PROCEDURE:

1. Connect the BNC T type adapter to the 4145A's VS channel 1 (Vs1) connector on the rear panel.

2. Connect VM channel 1 (Vm1) and the 3455A to VS channel 1 (Vs1) as shown in Figure 4-12.

3. Set the 3455A's controls as follows :

FUNCTION .... ⎓V
RANGE .... AUTO
TRIGGER .... INTERNAL
MATH .... OFF
AUTO CAL .... OFF
HIGH RESOLUTION .... ON

4. Set the 4145A's controls as follows :

i) On the CHANNEL DEFINITION page :

Set up the page as shown in Figure 4-13.

ii) On the SOURCE SET UP page :

Set up the page as shown in Figure 4-13.

[hp] *** CHANNEL DEFINITION ***

	NAME		SOURCE	
CHAN	V	I	MODE	FCTN
SMU1				
SMU2				
SMU3				
SMU4				
Vs 1	VS1	------	V	CONST
Vs 2		------	V	
Vm 1	VM1	------	----	-----
Vm 2		------	----	-----

USER FCTN	NAME (UNIT) = EXPRESSION
1	____( )=
2	____( )=

[hp] ****** SOURCE SET UP ******

	VAR1	VAR2
NAME		
SWEEP MODE		LINEAR
START		
STOP		-------
STEP		
NO. OF STEP		
COMPLIANCE		

CONSTANT	SOURCE	COMPLIANCE
VS1 V	2.0000V	-------

Figure 4-13. Measurement Setup.

[hp] ** MEAS & DISP MODE SET UP **

MEASUREMENT MODE: TIME DOMAIN

WAIT TIME	.00s
INTERVAL	.01s
NO. OF RDNGS	1

DISPLAY MODE: LIST

NAMES	VM1

Figure 4-13. Measurement Setup (Cont'd).

iii) On the MEAS & DISP MODE SET UP page:

Select LIST as the display mode for the measurement results.

5. Perform measurement by pressing the REPEAT key.

6. Record the readings on the 4145A for monitored voltage value VM1a and on the 3455A for Va, then end measurement by pressing the STOP key.

7. Repeat steps 4 through 6 for VS output -2 volts, then record the readings on the 4145A for monitored voltage value VM1b and on the 3455A for Vb.

8. Verify that the error and offset defined by the following equations satisfy the test limits listed in Table 4-11.

$$\text{error} = \frac{\text{VM1a} - \text{VM1b}}{\text{Va} - \text{Vb}} - 1$$

$$\text{offset} = \text{VM1a} - (1 + \text{error}) * \text{Va}$$

9. Repeat steps 4 through 7 for VS outputs 20 volts and -20 volts.

Table 4-11. Test Limits for VM Accuracy Test

VM Range Tested	2 volt		20 volt	
VS Output (volt)	2	-2	20	-20
Error (%)	±0.5		±0.2	
Offset	±10mV		±10mV	

4-14. EXTERNAL CRT X-Y-Z OUTPUT CHECK

PURPOSE: This check verifies that the external CRT X-Y-Z-signal is properly output.

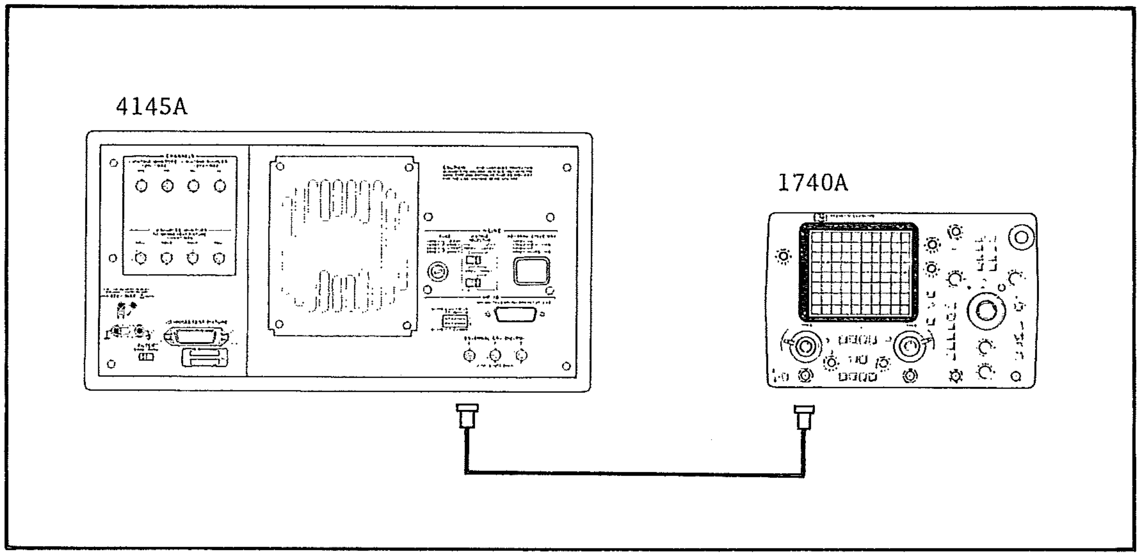


Figure 4-14. External CRT X-Y-Z Output Check Setup.

EQUIPMENT:

Oscilloscope .... HP MODEL 1740A
BNC (Male)-BNC (Male) Cable .... HP MODEL 11170B

PROCEDURE:

1. Turn off the 4145A.

2. Connect channel A (or channel B) input to the EXTERNAL CRT X-output as shown in Figure 4-14.

3. Set the 1740A's controls as follows:

   VOLT/DIV 0.2
   COUPLING .... DC
   TIME/DIV 0.5msec
   TRIGGER .... INT channel A

4. Insert one of the discs (software discs furnished with the 4145A) into the flexible-disc drive, then turn on the 4145A and the oscilloscope. The MENU page will be displayed on the CRT display.

5. Verify that 0V-1V signal is observed as shown in Figure 4-15.

6. Perform steps 1 through 5 for EXTERNAL CRT Y-output and Z-output. Verify that the scope displays are observed as shown in Figure 4-15.

X-output

Y-output

Z-output

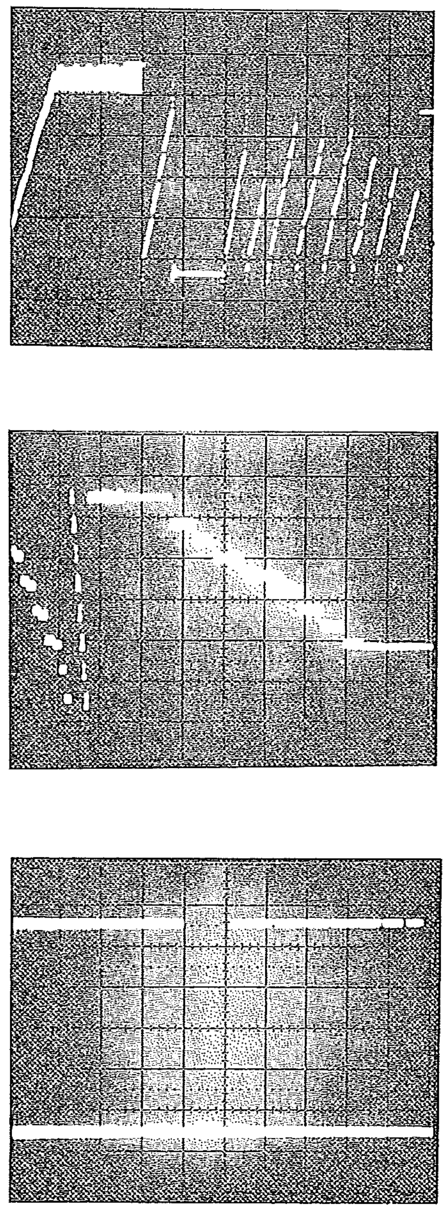


Figure 4-15. Scope Displays of X-Y-Z Output (Example).

4-15. HP-IB INTERFACE TEST

PURPOSE : This test verifies the instrument's HP-IB capabilities (see Table 3-8).

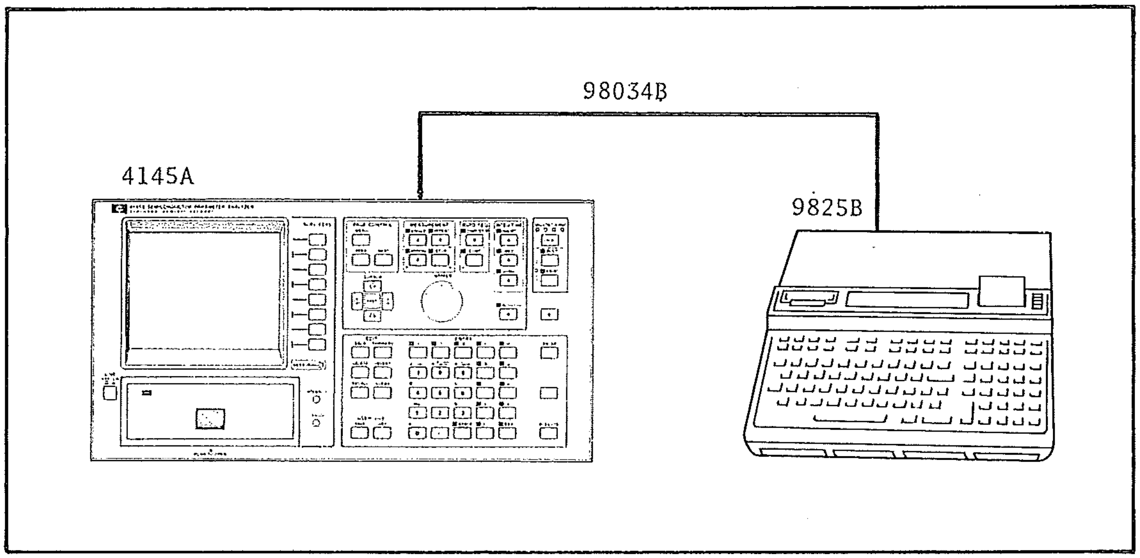


Figure 4-16. HP-IB Interface Test Setup.

EQUIPMENT :

Desktop Computer	HP MODEL 9825B
Interface Card with Cable	HP MODEL 98034B
I/O ROM's	HP MODEL 98210A and 98213A

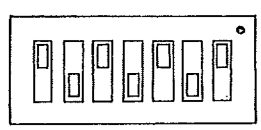
PROCEDURE :

1. Turn off both the 4145A and the 9825B.

2. Connect the 98034B between the 4145A and the 9825B as shown in Figure 4-16, and the I/O ROM's in the ROM slots.

3. Set the HP-IB control switch, located on the rear panel, as follows :

   bits 1 - 5 : 10101 (21_{10})
   bit 6 : 0
   bit 7 : 1



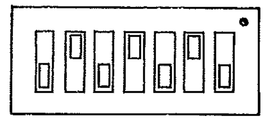
4. Turn on the 4145A.

5. After the MENU page has been displayed, verify that the HP-IB status message on the system message line is as follows :

   HP-IB (21 , COMMA ,)

6. Turn off the 4145A, then reset the HP-IB control switch as follows :

   bits 1 - 5 : 01010 (10_{10})
   bit 6 : 1
   bit 7 : 0

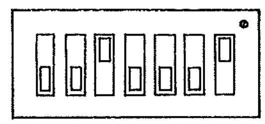


7. Turn on the 4145A, then verify that the HP-IB status message on the system message line is as follows :

   HP-IB (10, CR/LF, EOI)

8. Turn off the 4145A, then reset the HP-IB control switch as follows :

   bits 1 - 5 : 10001 (17_{10})
   bit 6 : 0
   bit 7 : 0



9. Turn on the 9825B and the 4145A.

10. Load the HP-IB Interface Test Program into the desktop computer (controller). The test program, listed in Figure 4-17, includes eight tests, listed in Table 4-12.

11. Execute the program and follow the prompts and instructions output by the controller. Details on controller instructions and appropriate operator responses are given in Table 4-13. An error message is printed out if any step of the test fails, then the test is discontinued. See Table 4-14 for explanations of error messages.

Note

The 16058A Test Fixture or shorting connector (P/N 04145-61623) must be connected to the 4145A and the fixture lid must be closed during the HP-IB interface Test.

Table 4-12. HP-IB Interface Test Program

HP-IB INTERFACE TEST PROGRAMS

DESCRIPTION:

The HP-IB Interface Test Program tests the 4145A's HP-IB interface capabilities. With the test program, The tests listed below are performed in the order listed.

TEST NO.	Test	(HP-IB) Capabilities Tested
1	PLOT & Data Transfer TEST	1. PLOT Function of the 4145A 2. Data Transfer via the HP-IB 3. Talk Only
2	Listener and Remote/Local Test	1. Listener 2. Remote/Local
3	Local Lockout Test	Local Lockout
4	Talker Test*	1. Talker 2. EOI (End or Identify) Output
5	IFC Test	Response of the 4145A to Interface Clear Command from the Controller
6	Device Clear Test	Device Clear
7	Trigger Test	Response of the 4145A to Group Execute Trigger
8	SRQ Line Test*	1. Service Request 2. Serial Poll

* The test for EOI output and the SRQ Line Test are performed automatically without operator response.

```
0: "**** 4145A HP-IB PERFORMANCE TEST PROGRAM **** 12/25/1981 ":
1: dim A$[500],B$[500],D$[32],E$[32]
2: lcl 7
3: 0}U}V}E;cmpU}U
4: time 30000;on err "ERR"
5: "4145A HP-IB PERFORMANCE TEST"}E$;gsb "SLOWDSP"
6: "PLOT & Data Transfer TEST"}E$;gsb "SLOWDSP"
7: dsp "Press PLOT then CONTINUE";beep;stp
8: dsp "Press EXECUTE(4145A)";beep
9: lcl 7
10: cmd 7,"U5"
11: 0}E
12: rds(7,J,J,R)}J
13: if bit(7,R);gsb "EOIF3"
14: if E;stp ;gto 6
15: for I=1 to 50
16: gsb "GETDIO"
17: next I
18: gsb "TRNS"
19: if D$[1,15]="H X X X X X X X";gto "PASS"
20: gsb "PRTDIO"
21: stp ;gto 3
22: "PASS":dsp "      *** PASS 1 ***";wait 2000
23: dsp "Press PLOT again,then CONTINUE ";beep;stp ;gto "L3"
24: "GETDIO":rdb(731)}R
25: band(R,U)}U;ior(R,V)}V;ret
26: "ERR":prt E$,"TIMEOUT ERROR"
27: fxd 0;prt " on line",erl
28: prt " ";prt " ";stp ;end
29: "PRTDIO":
30: prt "** STUCK BUS **"
31: prt "** DIO LINES **"
32: prt "8-7-6-5-4-3-2-1"
33: prt D$[1,15]
34: prt " ";prt "DIO8 must be H";prt " ";prt " ";ret
35: "TRNS":
36: eor(U,V)}U
37: "X X X X X X X X"}D$[1,15]
38: for I=0 to 7
39: 15-2*I}K
40: if bit(I,U)=1;gto 43
41: "H"}D$[K,K]
42: if bit(I,R);"L"}D$[K,K]
43: next I
44: ret
45: end
46: "L3":
47: 0}U}V;cmpU}U
48: 17}Y;beep;ent "HP-IB Address ? (default=17)",Y;700+Y}Y
49: "LISTENER REMOTE/LOCAL TEST"}E$;gsb "SLOWDSP"
50: dsp "LTN & RMT on ? (CONT)";rem Y;beep;stp
51: dsp "Press LOCAL,RMT } off ? (CONT)";rem Y;beep;stp
52: "LOCAL LOCKOUT TEST"}E$;gsb "SLOWDSP"
```

Figure 4-17. Program Listing of HP-IB Interface Test (Sheet 1 of 3).

```
53: dsp "Press LOCAL,RMT still on ?(CONT)";rem Y;llo 7;beep;stp
54: lcl 7
55: gto 58
56: 0→E;rds(7,K,L,M)→N;if bit(7,M)=1;gsb "EOIF3"
57: if E=1;gto 49
58: "TALKER TEST"→E$;gsb "SLOWDSP"
59: rem 7
60: dsp "TLK on & RMT off ? (CONT)";cmd 7,"?5"&char(Y-700+64);beep;stp
61: wrt Y,"USBCTV1";wait 100
62: red Y,A$;wait 100
63: wrt Y,"TV1";gsb "EOICHK"
64: "IFC TEST"→E$;gsb "SLOWDSP";cli 7
65: dsp "TLK off & RMT on ? (CONT)";beep;stp
66: gsb "DCLCHK"
67: gsb "TRGCHK"
68: gto "L2"
69: "EOICHK":
70: "EOI TEST (AUTO)"→E$;gsb "SLOWDSP"
71: 0→E
72: if rdb(Y)≠13;jmp 0
73: if bit(0,rds(7,M,M,M)→P)=1;gsb "EOIF1"
74: if E=1;stp ;gto 70
75: if rdb(Y)≠10;jmp 0
76: if bit(0,rds(7,M,M,M)→Q)=0;gsb "EOIF2"
77: if E=1;stp ;gto 70
78: dsp "*** PASS 2 ***";wait 2000;ret
79: "L2":
80: clr Y
81: "SRQ LINE TEST (AUTO)"→E$;gsb "SLOWDSP"
82: 0→E
83: gsb "GETBUS"
84: if bit(5,R)=1;gsb "SRQF1"
85: if E=1;stp ;gto 81
86: wrt Y,"Q"
87: gsb "GETBUS"
88: if bit(5,R)=0;gsb "SRQF2"
89: if E=1;stp ;gto 81
90: rds(Y)→S
91: if S≠66;prt "SERIAL POLL ERROR";prt "STATUS BYTE is ",dtoS,"(octal)";stp
92: dsp "*** PASS 5 ***";wait 2000
93: dsp "* 4145A HP-IB TEST COMPLETED *";beep;stp
94: gto 3
95: "DCLCHK":
96: "DEVICE CLEAR TEST (AUTO)"→E$;gsb "SLOWDSP"
97: clr 7
98: gsb "MENCHK"
99: if E=1;prt "DEVICE CLEAR (DCL) FAIL";stp ;gto 97
100: wrt Y,"SS"
101: clr Y
102: gsb "MENCHK"
103: if E=1;prt "SELECTED DEVICE CLEAR (SDC) FAIL";stp ;gto 101
104: dsp "*** PASS 3 ***";wait 2000
105: ret
106: "MENCHK":
```

Figure 4-17. Program Listing of HP-IB Interface Test (Sheet 2 of 3).

```
107: wrt Y,"PL"
108: red Y,A$
109: wrt Y,"PF"
110: 1→E
111: for I=1 to 497
112: if A$[I,I+3]="MENU";0→E;gto 114
113: next I
114: ret
115: "TRGCHK":
116: "TRIGGER TEST (AUTO)"→E$;gsb "SLOWDSP"
117: wrt Y,"DECH2;CH3;SMIN.5;DM2LI'I1';MD"
118: trg Y
119: wait 1000
120: wrt Y,"BCDO'I1'"
121: red Y,A$
122: "LVXCTN"→B$[1,6]
123: 1→E
124: for I=1 to 6
125: if A$[1,1]=B$[I,I];0→E;gto 126
126: next I
127: if E=1;prt "TRIGGER TEST FAIL";prt "OUTPUT DATA";prt A$;stp ;gto 116
128: dsp " *** PASS 4 ***";wait 300
129: ret
130: "EOIF1":prt "FAIL:EOI LOW FOR [CR]";1→E;ret
131: "EOIF2":prt "FAIL:EOI HIGH FOR [LF]";1→E;ret
132: "EOIF3":prt "FAIL:EOI LINE LOW";1→E;ret
133: "SRQF1":prt "FAIL:SRQ LINE LOW";1→E;ret
134: "SRQF2":prt "FAIL:SRQ LINE HIGH";1→E;ret
135: "SLOWDSP":""→D$;len(E$)→W;for W=1 to len(E$);E$[W,W]→D$[W,W];dsp D$
136: wait 30;next W;wait 600;ret
137: "GETBUS":rds(7,P,Q,R)→S
138: band(R,U)→U;ior(R,V)→V;ret
139: "#trk1-24":end
```

Figure 4-17. Program Listing of HP-IB Interface Test (Sheet 3 of 3).

Table 4-13. Controller Instructions and Operator Responses for HP-IB Interface Test Program

Controller Instructions Displayed	Operator Response/Description
4145A HP-IB PERFORMANCE TEST	
PLOT & Data Transfer TEST	
Press PLOT then CONTINUE.	Press the PLOT key of the 4145A, then press .
Press EXECUTE (4145A).	Press the EXECUTE key of the 4145A within thirty seconds, then verify that the TLK and PLOT lamps of the 4145A are lit.
*** PASS 1 ***	If all steps of the PLOT & Data Transfer Test are correct, this message is displayed.
Press PLOT again, then CONTINUE.	Press the PLOT key of the 4145A, then press .
HP-IB Address? (default = 17)	Input the 4145A's HP-IB address (17), then press .
LISTENER REMOTE/LOCAL TEST	
LTN & RMT on? (CONT)	Verify that the LTN and RMT lamps of the 4145A are lit, then press . If either of the lamps is not lit, end the test.
Press LOCAL, REMOTE → off?	Press the LOCAL key of the 4145A and verify that RMT lamp goes off. Then press . If the RMT lamp does not go off, end the test.
EOI TEST (AUTO)	The EOI Test is performed automatically.
*** PASS 2 ***	If all steps of the EOI Test are correct, this message is displayed.
IFC TEST	
TLK off & RMT on?	Verify that the TLK and RMT lamps of the 4145A are off and on, respectively, then press . If the lamps are not in the correct status, end the test.
DEVICE CLEAR TEST (AUTO)	The Device Clear Test is performed automatically.
*** PASS 3 ***	If all steps of the Device Clear Test are correct, this message is displayed.
TRIGGER TEST (AUTO)	The Trigger Test is performed automatically.
*** PASS 4 ***	If all steps of the Trigger Test are correct, this message is displayed.

Table 4-13. Controller Instructions and Operator Responses for HP-IB Interface Test Program (Cont'd)

Controller Instructions Displayed	Operator Response/Description
SRQ LINE TEST (AUTO)	The SRQ Line Test is performed automatically.
*** PASS 5 ***	If all steps of the SRQ Line Test are correct, this message is displayed.
4145A HP-IB TEST COMPLETED	The test has been passed.

Table 4-14. Error Messages for HP-IB Interface Test Program

(1) TIMEOUT ERROR

This error message is displayed if the HP-IB Handshake is not properly performed within thirty seconds*. Examples of the TIMEOUT ERROR message are described below:

PLOT & Data Tran sfer TEST TIMEOUT ERROR on line 27	The ATN line is connected to GND (ground).
PLOT & Data Tran sfer TEST TIMEOUT ERROR on line 10	One of lines NRFD, DAV, or NDAC for three-wire-handshake is connected to GND (ground).

* If the EXECUTE key of the 4145A is not pressed within thirty seconds after "Press EXECUTE (4145A)" has been displayed during the PLOT & Data Transfer Test.

Note

This error message may be displayed when the error is detected in other tests.

(2) STUCK BUS ERROR

This error message is displayed if any of the DIO lines (DIO 1 - 8) are shorted or disconnected. An example of the STUCK BUS ERROR message is described below.

** STUCK BUS ** ** DIO LINES ** 8-7-6-5-4-3-2-1 H X X X X L X X DIO8 must be H	The DIO3 line is stuck at low level, but the DIO8 line is at high level. Note This message is displayed only in the PLOT & Data Transfer Test.

Table 4-14. Error Messages for HP-IB Interface Test Program (Cont'd)

(3) SRQ LINE ERROR

This error message is displayed if the SRQ line is disconnected or shorted. There are two kinds of SRQ Line Error messages as described below.

Display	Description
FAIL:SRQ LINE LO W	The SRQ line stays LOW.
FAIL:SRQ LINE HI GH	The SRQ line stays HIGH.

(4) EOI LINE ERROR

This message is displayed if the EOI line is disconnected or shorted. Examples of the EOI LINE ERROR message are described below:

Display	Description
FAIL:EOI LINE LO W	The EOI line stays LOW.
FAIL:EOI HIGH FO R [LF]	The EOI line is at HIGH level when the LF (line feed) signal is output.

Note

When the HP-IB control switch for the EOI is turned off, this message is displayed.

(5) SERIAL POLL ERROR

After the Service Request function of the 4145A has been verified, this message is displayed along with status byte information of the 4145A if Serial Poll is not performed properly. In the test program, the Serial Poll test has been passed when the status byte from the 4145A is 102 (octal). An example of the SERIAL POLL ERROR message described below:

```
SERIAL POLL ERRO
R
STATUS BYTE is
            0.00
(octal)
```

Table 4-14. Error Messages for HP-IB Interface Test Program (Cont'd)

(6)	DEVICE CLEAR (DCL) FAIL This message is displayed if the 4145A does not respond to universal command DCL.
(7)	SELECTED DEVICE CLEAR (SDL) FAIL This message is displayed if the 4145A does not respond to addressed command SDC.
(8)	TRIGGER TEST ERROR This message is displayed if the 4145A does not respond properly to addressed command GET (Group Execute Trigger).

4145A/B Semiconductor Analyzer Performance Test Sheet

Serial Number ________________ Test Performed By ________________

Temperature ______ Date ____________

Humidity ______ Custodian _____________________

Voltage Control Accuracy Test

SMU 1

20V Range	40V Range	100V Range
0V = ____________	0V = ____________	0V = ____________
20V = ____________	40V = ____________	100V = ____________
-20V = ____________	-40V = ____________	-100V = ____________

SMU 2

20V Range	40V Range	100V Range
0V = ____________	0V = ____________	0V = ____________
20V = ____________	40V = ____________	100V = ____________
-20V = ____________	-40V = ____________	-100V = ____________

SMU 3

20V Range	40V Range	100V Range
0V = ____________	0V = ____________	0V = ____________
20V = ____________	40V = ____________	100V = ____________
-20V = ____________	-40V = ____________	-100V = ____________

SMU 4

20V Range	40V Range	100V Range
0V = ____________	0V = ____________	0V = ____________
20V = ____________	40V = ____________	100V = ____________
-20V = ____________	-40V = ____________	-100V = ____________

Voltage Measurement Accuracy Test

SMU 1

20V Range

(4145) V1a = __________ V1b = __________
(3455) Va = __________ Vb = __________

40V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

100V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

SMU 2

20V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

40V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

100V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

SMU 3

20V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

40V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

100V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

SMU 4

20V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

40V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

100V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

Current Measurement Accuracy Test

SMU 1

10E2

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E3

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E4

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E5

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E6

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E7

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E8

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

SMU 2

10E2

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E3

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E4

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E5

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E6

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E7

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E8

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

Current Measurement Accuracy Test

SMU 3

10E2

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E3

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E4

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E5

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E6

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E7

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E8

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

SMU 4

10E2

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E3

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E4

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E5

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E6

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E7

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E8

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

Current Control Accuracy Test

SMU 1	SMU 2	SMU 3	SMU 4
10E2	10E2	10E2	10E2
Va = ________	Va = ________	Va = ________	Va = ________
Vb = ________	Vb = ________	Vb = ________	Vb = ________
10E3	10E3	10E3	10E3
Va = ________	Va = ________	Va = ________	Va = ________
Vb = ________	Vb = ________	Vb = ________	Vb = ________

VS Accuracy Test

VS1	VS2
0V = ________	0V = ________
20V = ________	20V = ________
-20V = ________	-20V = ________

VM Accuracy Test

VM1	VM2
2V Range	2V Range
2V	2V
Vm1a = ________	Vm1a = ________
Va = ________	Va = ________
-2V	-2V
Vm1b = ________	Vm1b = ________
Vb = ________	Vb = ________
20V Range	20V Range
20V	20V
Vm1a = ________	Vm1a = ________
Va = ________	Va = ________
-20V	-20V
Vm1b = ________	Vm1b = ________
Vb = ________	Vb = ________

4145A/B Semiconductor Analyzer Performance Test Sheet

Serial Number ________________ Test Performed By ________________

Temperature ______ Date ____________

Humidity ______ Custodian _____________________

Voltage Control Accuracy Test

SMU 1

20V Range	40V Range	100V Range
0V = ____________	0V = ____________	0V = ____________
20V = ____________	40V = ____________	100V = ____________
-20V = ____________	-40V = ____________	-100V = ____________

SMU 2

20V Range	40V Range	100V Range
0V = ____________	0V = ____________	0V = ____________
20V = ____________	40V = ____________	100V = ____________
-20V = ____________	-40V = ____________	-100V = ____________

SMU 3

20V Range	40V Range	100V Range
0V = ____________	0V = ____________	0V = ____________
20V = ____________	40V = ____________	100V = ____________
-20V = ____________	-40V = ____________	-100V = ____________

SMU 4

20V Range	40V Range	100V Range
0V = ____________	0V = ____________	0V = ____________
20V = ____________	40V = ____________	100V = ____________
-20V = ____________	-40V = ____________	-100V = ____________

Voltage Measurement Accuracy Test

SMU 1

20V Range

(4145) V1a = __________ V1b = __________
(3455) Va = __________ Vb = __________

40V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

100V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

SMU 2

20V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

40V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

100V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

SMU 3

20V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

40V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

100V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

SMU 4

20V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

40V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

100V Range

V1a = __________ V1b = __________
Va = __________ Vb = __________

Current Measurement Accuracy Test

SMU 1

10E2

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E3

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E4

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E5

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E6

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E7

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E8

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

SMU 2

10E2

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E3

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E4

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E5

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E6

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E7

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E8

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

10E9

I1a = __________ I1b = __________
Va = __________ Vb = __________

Current Measurement Accuracy Test

SMU 3		SMU 4	
10E2		10E2	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________
10E3		10E3	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________
10E4		10E4	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________
10E5		10E5	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________
10E6		10E6	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________
10E7		10E7	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________
10E8		10E8	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________
10E9		10E9	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________
10E9		10E9	
I1a = ________	I1b = ________	I1a = ________	I1b = ________
Va = ________	Vb = ________	Va = ________	Vb = ________

Current Control Accuracy Test

SMU 1
10E2

Va = ___________
Vb = ___________

10E3

Va = ___________
Vb = ___________

SMU 2
10E2

Va = ___________
Vb = ___________

10E3

Va = ___________
Vb = ___________

SMU 3
10E2

Va = ___________
Vb = ___________

10E3

Va = ___________
Vb = ___________

SMU 4
10E2

Va = ___________
Vb = ___________

10E3

Va = ___________
Vb = ___________

VS Accuracy Test

VS1

0V = ___________
20V = ___________
-20V = ___________

VS2

0V = ___________
20V = ___________
-20V = ___________

VM Accuracy Test

VM1
2V Range
2V

Vm1a = ___________
Va = ___________

-2V

Vm1b = ___________
Vb = ___________

20V Range
20V

Vm1a = ___________
Va = ___________

-20V

Vm1b = ___________
Vb = ___________

VM2
2V Range
2V

Vm1a = ___________
Va = ___________

-2V

Vm1b = ___________
Vb = ___________

20V Range
20V

Vm1a = ___________
Va = ___________

-20V

Vm1b = ___________
Vb = ___________

PERFORMANCE TEST RECORD

Hewlett-Packard
Model 4145A
SEMICONDUCTOR PARAMETER ANALYZER — Tested by ____________

Serial Number ____________ — Date ____________

Paragraph	Test and Result						
4-9	Graphic Display Unit Intensity and Focus Check					Pass . Fail *	
4-10	Page and Key Function Check					Pass . Fail *	
4-11	SMU Accuracy Test						
4-11-(1)	Voltage Coutrol Accuracy Test						
	SMU Range Tested	Output from SMU	Test Limit	Actual Result			
				SMU1	SMU2	SMU3	SMU4
	20V	0V	0V±0.01V	____	____	____	____
		20V	20V±0.03V	____	____	____	____
		-20V	-20V±0.03V	____	____	____	____
	40V	0V	0V±0.02V	____	____	____	____
		40V	40V±0.06V	____	____	____	____
		-40V	-40V±0.06V	____	____	____	____
	100V	0V	0V±0.05V	____	____	____	____
		100V	100V±0.15V	____	____	____	____
		-100V	-100V±0.15V	____	____	____	____
4-11-(2)	Voltage Measurement Accuracy Test						
	SMU Range Tested	Error/ Offset	Test Limit	Actual Result			
				SMU1	SMU2	SMU3	SMU4
	20V	Error	±0.1%	____%	____%	____%	____%
		Offset	±10mV	____	____	____	____
	40V	Error	±0.1%	____%	____%	____%	____%
		Offset	±20mV	____	____	____	____
	100V	Error	±0.1%	____%	____%	____%	____%
		Offset	±50mV	____	____	____	____

* check (√) either Pass or Fail.

PERFORMANCE TEST RECORD

Paragraph	Test and Result
4-11-(3)	Current Measurement Accuracy Test

16340A Range	Error/ Offset	Test Limit	Actual Result SMU1	SMU2	SMU3	SMU4
$10^2\Omega$	Error	±0.3%	______%	______%	______%	______%
	Offset	±0.12mA	______	______	______	______
$10^3\Omega$	Error	±0.3%	______%	______%	______%	______%
	Offset	±12μA	______	______	______	______
$10^4\Omega$	Error	±0.3%	______%	______%	______%	______%
	Offset	±1.2μA	______	______	______	______
$10^5\Omega$	Error	±0.3%	______%	______%	______%	______%
	Offset	±0.12μA	______	______	______	______
$10^6\Omega$	Error	±0.3%	______%	______%	______%	______%
	Offset	±12nA	______	______	______	______
$10^7\Omega$	Error	±0.5%	______%	______%	______%	______%
	Offset	±1.2nA	______	______	______	______
$10^8\Omega$	Error	±0.5%	______%	______%	______%	______%
	Offset	±0.12nA	______	______	______	______
$10^9\Omega$	Error	±1%	______%	______%	______%	______%
	Offset	±17pA	______	______	______	______
$10^9\Omega$	Error	±1%	______%	______%	______%	______%
	Offset	±6.2pA	______	______	______	______

Paragraph	Test and Result
4-11-(4)	Current Control Accuracy Test

16340A Range	Error/ Offset	Test Limit	Actual Result SMU1	SMU2	SMU3	SMU4
$10^2\Omega$	Error	±0.3%	______%	______%	______%	______%
	Offset	±0.12mA	______	______	______	______
$10^3\Omega$	Error	±0.3%	______%	______%	______%	______%
	Offset	±12μA	______	______	______	______

Paragraph	Test and Result
4-12	VS Accuracy Test

Output From VS	Test Limit	Actual Result VS1	VS2
0V	0V±0.01V		
20V	20V±0.11V		
-20V	-20V±0.11V		

PERFORMANCE TEST RECORD

<table>
<tr><th>Paragraph</th><th colspan="6">Test and Result</th></tr>
<tr><td rowspan="10">4-13</td><td colspan="6">VM Accuracy Test</td></tr>
<tr><td rowspan="2">VM Range Tested</td><td rowspan="2">Output from VS</td><td rowspan="2">Error/ Offset</td><td rowspan="2">Test Limit</td><td colspan="2">Actual Result</td></tr>
<tr><td>VM1</td><td>VM2</td></tr>
<tr><td rowspan="4">2V</td><td rowspan="2">2V</td><td>Error</td><td>±0.5%</td><td>______%</td><td>______%</td></tr>
<tr><td>Offset</td><td>±10mV</td><td>______</td><td>______</td></tr>
<tr><td rowspan="2">-2V</td><td>Error</td><td>±0.5%</td><td>______%</td><td>______%</td></tr>
<tr><td>Offset</td><td>±10mV</td><td>______</td><td>______</td></tr>
<tr><td rowspan="4">20V</td><td rowspan="2">20V</td><td>Error</td><td>±0.2%</td><td>______%</td><td>______%</td></tr>
<tr><td>Offset</td><td>±10mV</td><td>______</td><td>______</td></tr>
<tr><td rowspan="2">-20V</td><td>Error</td><td>±0.2%</td><td>______%</td><td>______%</td></tr>
<tr><td></td><td>Offset</td><td>±10mV</td><td>______</td><td>______</td></tr>
<tr><td rowspan="4">4-14</td><td rowspan="4" colspan="2">External CRT X-Y-Z Output Check</td><td colspan="2">Output</td><td colspan="2">Result*</td></tr>
<tr><td colspan="2">X-output</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="2">Y-output</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="2">Z-output</td><td colspan="2">Pass · Fail</td></tr>
<tr><td rowspan="7">4-15</td><td colspan="4">HP-IB Interface Test</td><td colspan="2">Result*</td></tr>
<tr><td colspan="4">(1) HP-IB Control Switch Function
"HP-IB (21, COMMA,)" and "HP-IB (21, CR/LF, EOI)" are displayed on the CRT.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(2) PLOT & Data Transfer Test
"***PASS 1***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(3) Listener and Remote/Local Test, Local Lockout Test, and Talker Test, EOI Test
"***PASS 2***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(4) IFC Test and Device Clear Test
"***PASS 3***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(5) Trigger Test
"***PASS 4***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(6) SRQ Line Test
"***PASS 5***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
</table>

* check (✓) either Pass or Fail.

PERFORMANCE TEST RECORD

Hewlett-Packard
Model 4145A
SEMICONDUCTOR PARAMETER ANALYZER

Tested by ________________

Serial Number ________________

Date ________________

<table>
<tr><th>Paragraph</th><th colspan="7">Test and Result</th></tr>
<tr><td>4-9</td><td colspan="7">Graphic Display Unit Intensity and Focus Check — Pass . Fail *</td></tr>
<tr><td>4-10</td><td colspan="7">Page and Key Function Check — Pass . Fail *</td></tr>
<tr><td>4-11</td><td colspan="7">SMU Accuracy Test</td></tr>
<tr><td rowspan="12">4-11-(1)</td><td colspan="7">Voltage Coutrol Accuracy Test</td></tr>
<tr><td rowspan="2">SMU Range Tested</td><td rowspan="2">Output from SMU</td><td rowspan="2">Test Limit</td><td colspan="4">Actual Result</td></tr>
<tr><td>SMU1</td><td>SMU2</td><td>SMU3</td><td>SMU4</td></tr>
<tr><td rowspan="3">20V</td><td>0V</td><td>0V±0.01V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td>20V</td><td>20V±0.03V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td>-20V</td><td>-20V±0.03V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td rowspan="3">40V</td><td>0V</td><td>0V±0.02V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td>40V</td><td>40V±0.06V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td>-40V</td><td>-40V±0.06V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td rowspan="3">100V</td><td>0V</td><td>0V±0.05V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td>100V</td><td>100V±0.15V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td>-100V</td><td>-100V±0.15V</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td rowspan="9">4-11-(2)</td><td colspan="7">Voltage Measurement Accuracy Test</td></tr>
<tr><td rowspan="2">SMU Range Tested</td><td rowspan="2">Error/ Offset</td><td rowspan="2">Test Limit</td><td colspan="4">Actual Result</td></tr>
<tr><td>SMU1</td><td>SMU2</td><td>SMU3</td><td>SMU4</td></tr>
<tr><td rowspan="2">20V</td><td>Error</td><td>±0.1%</td><td>____%</td><td>____%</td><td>____%</td><td>____%</td></tr>
<tr><td>Offset</td><td>±10mV</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td rowspan="2">40V</td><td>Error</td><td>±0.1%</td><td>____%</td><td>____%</td><td>____%</td><td>____%</td></tr>
<tr><td>Offset</td><td>±20mV</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
<tr><td rowspan="2">100V</td><td>Error</td><td>±0.1%</td><td>____%</td><td>____%</td><td>____%</td><td>____%</td></tr>
<tr><td>Offset</td><td>±50mV</td><td>____</td><td>____</td><td>____</td><td>____</td></tr>
</table>

* check (✓) either Pass or Fail.

PERFORMANCE TEST RECORD

Paragraph	Test and Result
4-11-(3)	Current Measurement Accuracy Test

16340A Range	Error/ Offset	Test Limit	Actual Result SMU1	SMU2	SMU3	SMU4
$10^2\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±0.12mA	____	____	____	____
$10^3\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±12µA	____	____	____	____
$10^4\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±1.2µA	____	____	____	____
$10^5\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±0.12µA	____	____	____	____
$10^6\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±12nA	____	____	____	____
$10^7\Omega$	Error	±0.5%	____%	____%	____%	____%
	Offset	±1.2nA	____	____	____	____
$10^8\Omega$	Error	±0.5%	____%	____%	____%	____%
	Offset	±0.12nA	____	____	____	____
$10^9\Omega$	Error	±1%	____%	____%	____%	____%
	Offset	±17pA	____	____	____	____
$10^9\Omega$	Error	±1%	____%	____%	____%	____%
	Offset	±6.2pA	____	____	____	____

Paragraph	Test and Result
4-11-(4)	Current Control Accuracy Test

16340A Range	Error/ Offset	Test Limit	Actual Result SMU1	SMU2	SMU3	SMU4
$10^2\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±0.12mA	____	____	____	____
$10^3\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±12µA	____	____	____	____

Paragraph	Test and Result
4-12	VS Accuracy Test

Output From VS	Test Limit	Actual Result VS1	VS2
0V	0V±0.01V		
20V	20V±0.11V		
-20V	-20V±0.11V		

PERFORMANCE TEST RECORD

<table>
<tr><th>Paragraph</th><th colspan="6">Test and Result</th></tr>
<tr><td rowspan="10">4-13</td><td colspan="6">VM Accuracy Test</td></tr>
<tr><td rowspan="2">VM Range Tested</td><td rowspan="2">Output from VS</td><td rowspan="2">Error/ Offset</td><td rowspan="2">Test Limit</td><td colspan="2">Actual Result</td></tr>
<tr><td>VM1</td><td>VM2</td></tr>
<tr><td rowspan="4">2V</td><td rowspan="2">2V</td><td>Error</td><td>±0.5%</td><td>______%</td><td>______%</td></tr>
<tr><td>Offset</td><td>±10mV</td><td>______</td><td>______</td></tr>
<tr><td rowspan="2">-2V</td><td>Error</td><td>±0.5%</td><td>______%</td><td>______%</td></tr>
<tr><td>Offset</td><td>±10mV</td><td>______</td><td>______</td></tr>
<tr><td rowspan="4">20V</td><td rowspan="2">20V</td><td>Error</td><td>±0.2%</td><td>______%</td><td>______%</td></tr>
<tr><td>Offset</td><td>±10mV</td><td>______</td><td>______</td></tr>
<tr><td rowspan="2">-20V</td><td>Error</td><td>±0.2%</td><td>______%</td><td>______%</td></tr>
<tr><td>Offset</td><td>±10mV</td><td>______</td><td>______</td></tr>
<tr><td rowspan="4">4-14</td><td colspan="2" rowspan="4">External CRT X-Y-Z Output Check</td><td colspan="2">Output</td><td colspan="2">Result*</td></tr>
<tr><td colspan="2">X-output</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="2">Y-output</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="2">Z-output</td><td colspan="2">Pass · Fail</td></tr>
<tr><td rowspan="7">4-15</td><td colspan="4">HP-IB Interface Test</td><td colspan="2">Result*</td></tr>
<tr><td colspan="4">(1) HP-IB Control Switch Function
"HP-IB (21, COMMA,)" and "HP-IB (21, CR/LF, EOI)" are displayed on the CRT.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(2) PLOT & Data Transfer Test
"***PASS 1***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(3) Listener and Remote/Local Test, Local Lockout Test, and Talker Test, EOI Test
"***PASS 2***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(4) IFC Test and Device Clear Test
"***PASS 3***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(5) Trigger Test
"***PASS 4***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
<tr><td colspan="4">(6) SRQ Line Test
"***PASS 5***" is displayed on the 9825B.</td><td colspan="2">Pass · Fail</td></tr>
</table>

* check (✓) either Pass or Fail.

PERFORMANCE TEST RECORD

Hewlett-Packard
Model 4145A
SEMICONDUCTOR PARAMETER ANALYZER

Tested by ____________________

Serial Number ____________________

Date ____________________

Paragraph	Test and Result
4-9	Graphic Display Unit Intensity and Focus Check — Pass . Fail *
4-10	Page and Key Function Check — Pass . Fail *
4-11	SMU Accuracy Test
4-11-(1)	Voltage Coutrol Accuracy Test

SMU Range Tested	Output from SMU	Test Limit	Actual Result SMU1	SMU2	SMU3	SMU4
20V	0V	0V±0.01V	______	______	______	______
	20V	20V±0.03V	______	______	______	______
	-20V	-20V±0.03V	______	______	______	______
40V	0V	0V±0.02V	______	______	______	______
	40V	40V±0.06V	______	______	______	______
	-40V	-40V±0.06V	______	______	______	______
100V	0V	0V±0.05V	______	______	______	______
	100V	100V±0.15V	______	______	______	______
	-100V	-100V±0.15V	______	______	______	______

Paragraph	Test and Result
4-11-(2)	Voltage Measurement Accuracy Test

SMU Range Tested	Error/ Offset	Test Limit	Actual Result SMU1	SMU2	SMU3	SMU4
20V	Error	±0.1%	______%	______%	______%	______%
	Offset	±10mV	______	______	______	______
40V	Error	±0.1%	______%	______%	______%	______%
	Offset	±20mV	______	______	______	______
100V	Error	±0.1%	______%	______%	______%	______%
	Offset	±50mV	______	______	______	______

* check (✓) either Pass or Fail.

PERFORMANCE TEST RECORD

Paragraph	Test and Result
4-11-(3)	Current Measurement Accuracy Test

16340A Range	Error/ Offset	Test Limit	Actual Result SMU1	SMU2	SMU3	SMU4
$10^2\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±0.12mA	____	____	____	____
$10^3\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±12μA	____	____	____	____
$10^4\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±1.2μA	____	____	____	____
$10^5\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±0.12μA	____	____	____	____
$10^6\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±12nA	____	____	____	____
$10^7\Omega$	Error	±0.5%	____%	____%	____%	____%
	Offset	±1.2nA	____	____	____	____
$10^8\Omega$	Error	±0.5%	____%	____%	____%	____%
	Offset	±0.12nA	____	____	____	____
$10^9\Omega$	Error	±1%	____%	____%	____%	____%
	Offset	±17pA	____	____	____	____
$10^9\Omega$	Error	±1%	____%	____%	____%	____%
	Offset	±6.2pA	____	____	____	____

Paragraph	Test and Result
4-11-(4)	Current Control Accuracy Test

16340A Range	Error/ Offset	Test Limit	Actual Result SMU1	SMU2	SMU3	SMU4
$10^2\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±0.12mA	____	____	____	____
$10^3\Omega$	Error	±0.3%	____%	____%	____%	____%
	Offset	±12μA	____	____	____	____

Paragraph	Test and Result
4-12	VS Accuracy Test

Output From VS	Test Limit	Actual Result VS1	VS2
0V	0V±0.01V		
20V	20V±0.11V		
-20V	-20V±0.11V		

PERFORMANCE TEST RECORD

Paragraph	Test and Result					
4-13	VM Accuracy Test					
	VM Range Tested	Output from VS	Error/ Offset	Test Limit	Actual Result VM1	Actual Result VM2
	2V	2V	Error	±0.5%	______%	______%
			Offset	±10mV	______	______
		-2V	Error	±0.5%	______%	______%
			Offset	±10mV	______	______
	20V	20V	Error	±0.2%	______%	______%
			Offset	±10mV	______	______
		-20V	Error	±0.2%	______%	______%
			Offset	±10mV	______	______

Paragraph	Test	Output	Result*
4-14	External CRT X-Y-Z Output Check	X-output	Pass · Fail
		Y-output	Pass · Fail
		Z-output	Pass · Fail

Paragraph	Test	Result*
4-15	HP-IB Interface Test	
	(1) HP-IB Control Switch Function "HP-IB (21, COMMA,)" and "HP-IB (21, CR/LF, EOI)" are displayed on the CRT.	Pass · Fail
	(2) PLOT & Data Transfer Test "***PASS 1***" is displayed on the 9825B.	Pass · Fail
	(3) Listener and Remote/Local Test, Local Lockout Test, and Talker Test, EOI Test "***PASS 2***" is displayed on the 9825B.	Pass · Fail
	(4) IFC Test and Device Clear Test "***PASS 3***" is displayed on the 9825B.	Pass · Fail
	(5) Trigger Test "***PASS 4***" is displayed on the 9825B.	Pass · Fail
	(6) SRQ Line Test "***PASS 5***" is displayed on the 9825B.	Pass · Fail

* check (✓) either Pass or Fail.

SECTION V
ADJUSTMENT

5-1. INTRODUCTION

5-2. This section provides the information needed to adjust the 4145A to the specifications listed in Table 1-1. The prime purpose of adjustment is to return the instrument to its peak operating capabilities after repairs have been made. The instrument should be tested and adjusted whenever a part or component has been replaced. If the instrument falls out of adjustment, readjustment alone often returns the instrument to normal operating conditions without repairs. Adjustment procedures should also be performed periodically to maintain top operating performance. The recommended adjustment schedule for the 4145A is every six months. All adjustable components referred to in individual tests are listed in Table 5-1. If proper performance cannot be achieved after adjustment procedures have been performed, refer to the troubleshooting procedures described in Section VIII.

Note

To ensure proper adjustment and instrument operation, allow 40 minute warm-up time to stabilize operating conditions before performing any of the adjustment procedures described herein.

5-3. SAFETY REQUIREMENTS

5-4. Although the instrument has been designed in accordance with international safety standards, this manual contains supplementary information, cautions, and warnings which must be followed to ensure safe operating conditions (see Section II and III). Adjustments described in this section should be performed only by qualified service personnel.

WARNING

ANY DISTURBANCE OF THE PROTECTIVE (GROUNDED) CONDUCTOR INSIDE OR OUTSIDE THE INSTRUMENT, OR DISCONNECTION OF THE PROTECTIVE GROUND TERMINAL CAN MAKE THE INSTRUMENT UNSAFE. INTENTIONAL INTERRUPTION FOR ANY REASON IS PROHIBITED.

5-5. Opening covers in order to remove parts, except those which can be accessed by hand, exposes live components and terminals. Use appropriate caution.

5-6. Capacitors in the instrument may still be charged after the instrument has been disconnected from the power source.

WARNING

ADJUSTMENTS DESCRIBED IN THIS SECTION ARE PERFORMED WITH POWER SUPPLIED TO THE INSTRUMENT AND WITH PROTECTIVE COVERS REMOVED. ELECTRICAL CURRENT EXISTING AT MANY POINTS MAY, IF CONTACTED, RESULT IN SERIOUS PERSONAL INJURY.

5-7. EQUIPMENT REQUIRED

5-8. Equipment needed to adjust the 4145A is listed in Table 4-1. Each piece of equipment listed in Table 4-1 must be calibrated to satisfy its own specifications and required characteristics. If the recommended model is not available, any instrument whose specifications equal to or surpass the required specifications may be substituted.

5-9. ADJUSTMENT RELATIONSHIPS

5-10. The adjustment procedures described in this section, beginning with paragraph 5-24, should be performed in the order described because each step is interactive. Neglecting or changing the order of the procedures may make it impossible to obtain optimum instrument performance. Table 5-2 lists necessary adjustment procedures after the instrument has been repaired.

5-11. ADJUSTMENT LOCATIONS

5-12. To help locate the appropriate adjustment points, brief descriptions of their locations are given in each adjustment section. Refer to Section VIII for overall component locations. The locations, connectors, and other components related to the adjustment are shown in the individual board assembly component illustrations (fold-out service sheets).

Table 5-1. Adjustable Components

Paragraph	Reference Disignator	Name of Control	Description
5-23	INTENSITY FOCUS	INTENSITY FOCUS	Adjusts the writing beam intensity and focus.
5-24	A11R17	V ADJ	Adjusts the power supply voltage by adjusting switching duty cycle.
5-25	A3R30	C ADJ	Eliminates AC offset generated in the sample hold switch.
5-26	A4C1 A4C2 A4C3 A4C4 A4C5 A4C6 A4C7 A4C8 A4C9 A4C10	I1 V1 I2 V2 I3 V3 I4 V4 E1 E2	Eliminates AC offset generated in the demultiplexer.
5-27	A4R11	GAIN	Adjusts the gain of the D-A converter for analog output.
5-28	A3R1	AD GAIN	Adjusts the gain of the A-D converter.
5-29	A16R4 A16R104	G ADJ G ADJ	Adjusts the gain of Voltage Monitor 1 (Vm 1) and Voltage Monitor (Vm 2).
5-52	DRIVE MOTOR		Adjusts the drive belt tension for optimum read/write capability of the flexible-disc drive.
5-53	R47		Adjusts the index timing for correct sector selection.
5-54	STEPPER MOTOR		Adjusts the track alignment for accessing a specified track.
5-55	TRACK ZERO SWITCH		Adjusts the switching timing of the track zero switch.
5-56	R69		Minimizes jitter in read data for proper read data sampling.
5-57	INDEX DETECTOR		Adjusts the index detector alignment for correct sector selection.

5-13. INITIAL OPERATING PROCEDURES

5-14. Before making the adjustments described starting in paragraph 5-23, perform the procedures described in paragraph 5-15 through 5-22 to locate and to gain access to adjustment controls. These procedures provide access to the various adjustment points and facilitate thoroughgoing adjustment. The Initial Control Settings described in paragraph 3-14 must be used for each adjustment, and COM (COMMON)-GROUND terminals, located on the rear panel, must be shorted using the shorting bar.

5-15. BASIC OPERATING CHECKS

5-16. Check that the instrument's line voltage selector switches, located on the rear panel, are set for the local line voltage. This should be performed before making any adjustments.

After the recommended 40 minute warm-up period, the instrument should pass the SELF TEST (no error messages appear), and the initial control settings should be automatically set in preparation for measurement. If the instrument displays an error message or does not have the correct initial control settings, refer to the troubleshooting procedures given in Section VIII.

5-17. TOP COVER REMOVAL

5-18. Remove the top cover in order to gain access to the adjustment controls as follows :

(1) Fully loosen the retaining screw at the rear of the top cover.

(2) Slide the top cover towards the rear and lift off.

5-19. BOTTOM COVER REMOVAL

5-20. Remove the bottom cover in order to gain access to the adjustment controls as follows:

(1) Fully loosen the retaining screw at the rear of the bottom cover.

(2) Slide the bottom cover towards the rear and lift off.

WARNING

WHEN TOP COVER OR BOTTOM COVER IS REMOVED, LIVE COMPONENTS ARE EXPOSED.

5-21. A3 BOARD ACCESS

5-22. The following adjustments procedure and A3S1 switch settings are facilitated by extending the A3 SMU Control and A-D Converter Board with an extender board (HP P/N : 04145-66521). The seven bits of A3S1 are initially set to all zeros (0000000) and changed as necessary to set the 4145A in test mode. Refer to each adjustment procedure for the required setting.

(1) Sample Hold Switch AC Offset Adjustment

(2) Demultiplexer Noise Rejection Adjustment

(3) D-A Converter Gain Adjustment

(4) A-D Converter Gain Adjustment

Note

For the above adjustments, the following messages are displayed on the system message line in the order given after the 4145A has been turned on.

(1) Busy

(2) Error A01
——about 30 second interval——

(3)* HP-IB (XX, COMMA, EOI)
FILTER (XX HZ)
CHAN (!!!DOWN!!!)

* This message is displayed on the MENU page.

These messages are shown only because the 4145A is in the test mode, and indicate that the 4145A is functioning properly.

WARNING

TO GUARD AGAINST ELECTRICAL SHOCK, USE INSULATED TOOLS FOR ALL ADJUSTMENTS.

Table 5-2. Adjustment Requirements

Assembly Repaired or Replaced	Required Checks/Adjustments
A1 Graphics Display Control Board (P/N: 04145-66501)	None
A2 Microprocessor Digital Control Board (P/N: 04145-66502)	None
A3 SMU Control and A-D Converter Board (P/N: 04145-66503)	Para. 5-25 and -28
A4 D-A Converter Board (P/N: 04145-66504)	Para. 5-26 and -27
A5 SMU Board (P/N: 04145-66505)	None
A9 HP-IB and MSU Control Board (P/N: 04145-66509)	None
A10 Keyboard and Display Control Board (P/N: 04145-66510)	None
A11 Switching Power Supply Board (P/N: 04145-66511)	Para. 5-24
A12 DC Power Supply Board (P/N: 04145-66512)	None
A13 SMU Power Source Board (P/N: 04145-66513)	None
A15 Floating Power Supply Board (P/N: 04145-66515)	None
A16 Vs/Vm Board (P/N: 04145-66516)	Para. 5-29

Table 5-2. Adjustment Requirements (Cont'd)

Assembly Repaired or Replaced	Required Checks/Adjustments
Graphics Display Unit (HP 1345A)	Refer to the 1345A's manual.
Flexible-disc Drive (P/N: 0950-0863)	Para. 5-43 and -46
(1) PC Board Assembly (P/N: 04145-65110) Replacement	Para. 5-53, -56, and -57
(2) Drive Belt (P/N: 04145-65114) Replacement	Para. 5-52 and -53
(3) Head Carriage Assembly (P/N: 04145-65112) Replacement	Para. 5-54, -55, and -56
(4) Front Cabinet Assembly (P/N: 04145-65113) Replacement	Para. 5-53, -56, and -57
(5) Drive Motor Assembly (P/N: 04145-65111) Replacement	Para. 5-52 and -53
(6) LED (P/N: 04145-65115) for write-protection	Verify that the write-protect function works properly.
(7) LED (P/N: 04145-65115) for Index Detector	Para. 5-57
(8) Phototransistor (P/N: 04145-65116) for write-protection	Verify that the write-protect function works properly.
(9) Phototransistor (P/N: 04145-65116) for index detection	Para. 5-57

ADJUSTMENTS

5-23. GRAPHICS DISPLAY UNIT INTENSITY AND FOCUS CHECK AND ADJUSTMENT

PURPOSE: This check and adjustment sets intensity and focus of the 4145A Graphic Display Unit (GDU) for clear display.

PROCEDURE:

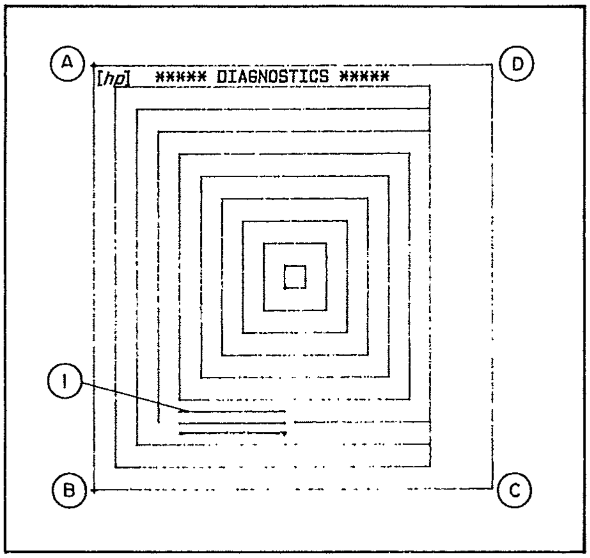


Figure 5-1. Test Pattern for GDU.

1. Obtain the DIAGNOSTICS page by pressing the EXTN softkey and the DIAG softkey while viewing the MENU page.

2. Display the test pattern (Figure 5-1) by pressing the G.D. TEST softkey.

3. Adjust INTENSITY with an insulated screwdriver until line 1 (see Figure 5-1) is just barely visible. Refer to Figure 5-2 for the INTENSITY adjustment location.

4. Adjust FOCUS for sharp, well-defined trace at points A, B, C, and D first, then over the entire CRT. Refer to Figure 5-2 for the FOCUS adjustment location.

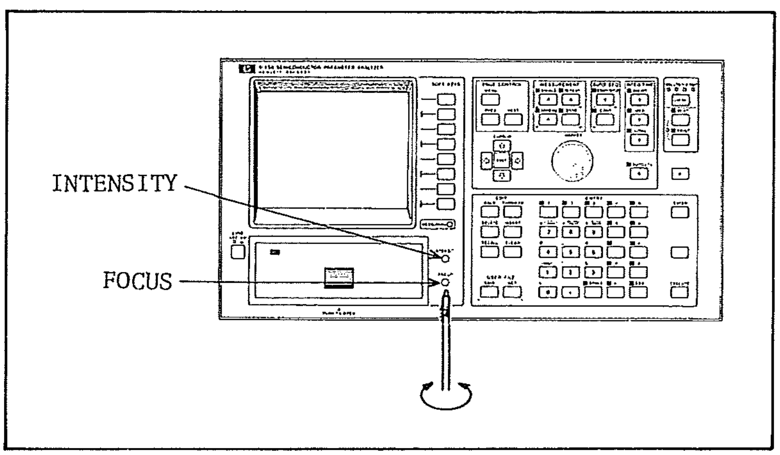


Figure 5-2. INTENSITY and FOCUS Locations.

ADJUSTMENTS

Note 1

If the writing beam intensity and focus cannot be properly adjusted or if any distortion of trace is observed, refer to Section IV and V of the 1345A's Operating and Service Manual, located at the back of this binder.

Note 2

When the procedures in Section IV and V of the 1345A's Operating and Service manual are performed, the connector on the 4145A's A1 GDU Control Board must be disconnected. See Figure 5-3 for the connector location.

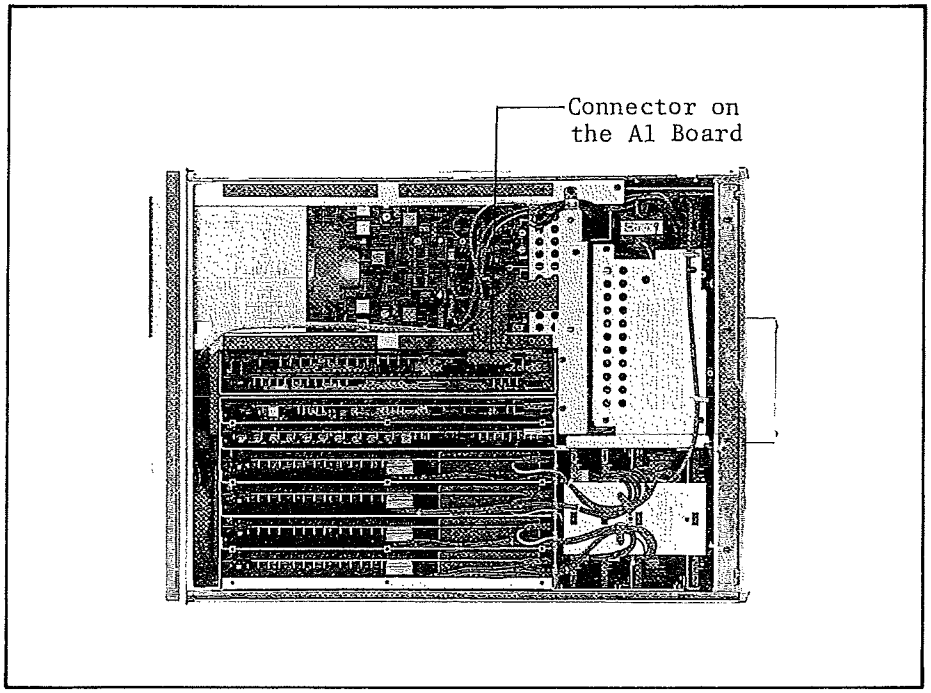


Figure 5-3. Connector Location.

5-24. DC POWER SUPPLY ADJUSTMENT

PURPOSE: This adjustment accurately sets the regulated power supply output voltage for all sections of the 4145A.

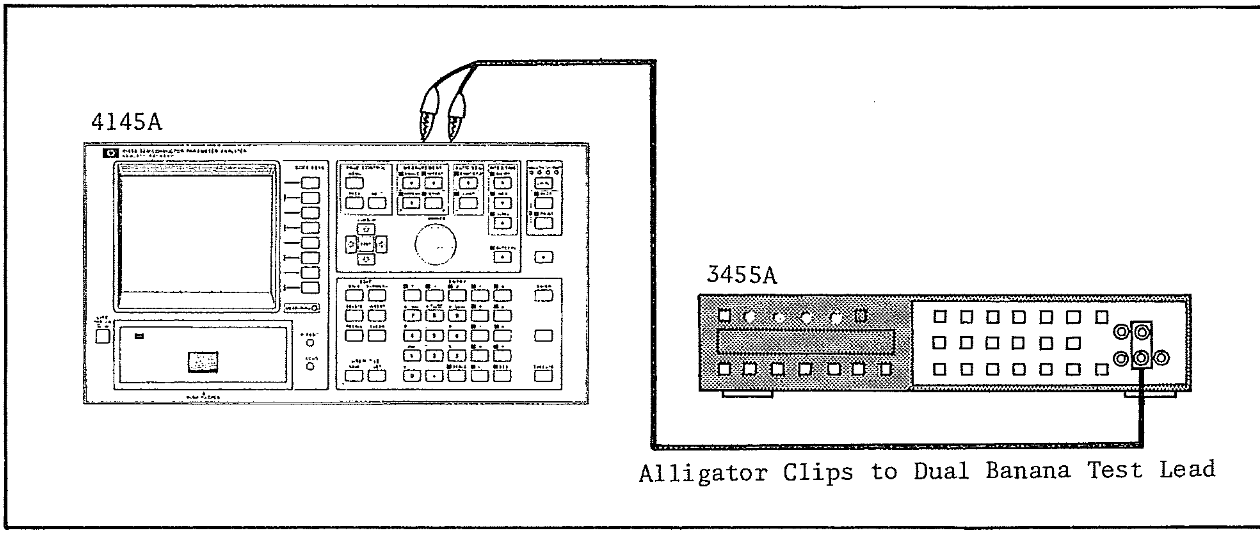


Figure 5-4. DC Power Supply Adjustment Setup.

EQUIPMENT:

DVM*	HP MODEL 3455A
Test Lead (alligator clips to dual banana plug)	HP MODEL 11002A
Test Lead (probe and alligator clip to dual banana plug)	HP MODEL 11003A

*DVM must have at least 3 1/2 digit display capability.

PROCEDURE:

1. Connect the DVM HI input to A2TP16 (+5V) (see Figure 5-7 for the location), and the LOW input to the chassis using an alligator clip-to-dual banana plug test lead.

2. Set the 3455A's controls as follows:

FUNCTION	⎓V
RANGE	AUTO
TRIGGER	INTERNAL

3. Disconnect the test fixture and cables from the 4145A, then turn on the 4145A and the 3455A.

Note

Perform adjustment and checks while viewing the MENU page.

ADJUSTMENTS

4. Adjust A11R17 (see Figure 5-6 for location) until the reading on the DVM is between 5.040V and 5.065V when 100 volt power line voltage is used. Use an insulated screwdriver.

Note

When 115 or 220 volt power line voltage is used, the limit is between 5.050V and 5.075V.

WARNING

A11R17 IS LOCATED BENEATH THE SHIELD ON THE A11 BOARD. DO NOT REMOVE THE SHIELD FOR THIS ADJUSTMENT. DC VOLTAGES EXCEEDING 100V ARE PRESENT ON THE A11 BOARD.

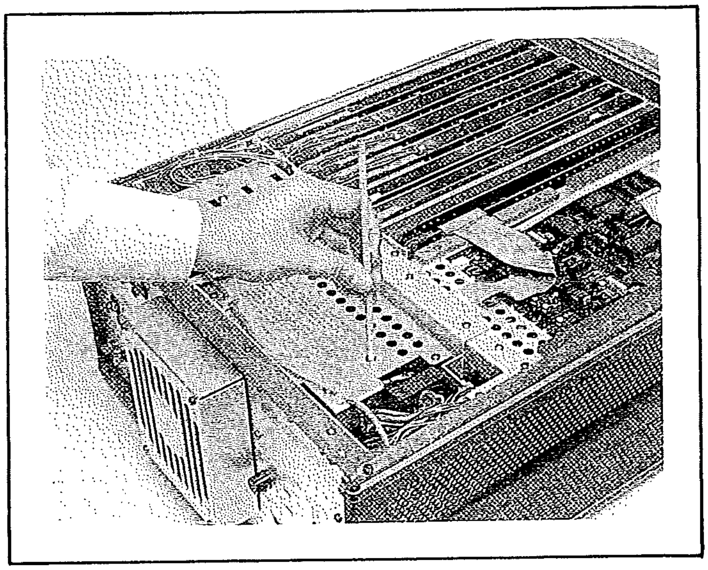


Figure 5-5. A11R17 Adjustment.

5. Connect the DVM to the points listed in Table 5-3, and verify that the DVM readout at each point is within the limits given in the table. Refer to Figure 5-7 for the locations of the points listed in Table 5-3.

WARNING

WHEN A5J1 PIN 1 AND A5J1 PIN10 ARE CHECKED, THE 11003A TEST LEAD (PROBE AND ALLIGATOR CLIP TO DUAL BANANA) SHOULD BE USED FOR THE CHECK. IF THE TEST LEAD IS NOT AVAILABLE, USE THE 11002A TEST LEAD WITH A SHORT WIRE AS SHOWN IN FIGURE 5-6, BUT BE CAREFUL. DC VOLTAGE EXCEEDING 100V IS PRESENT AT THE CHECK POINT.

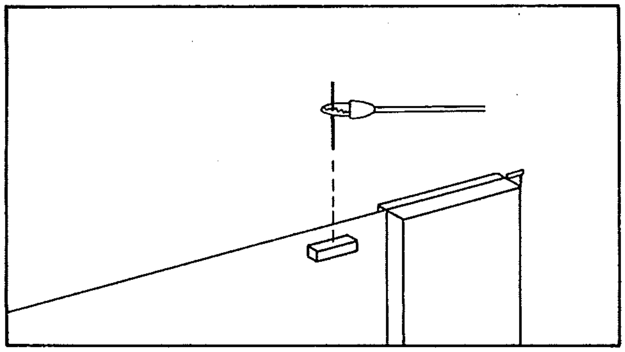


Figure 5-6. A5J1 Check.

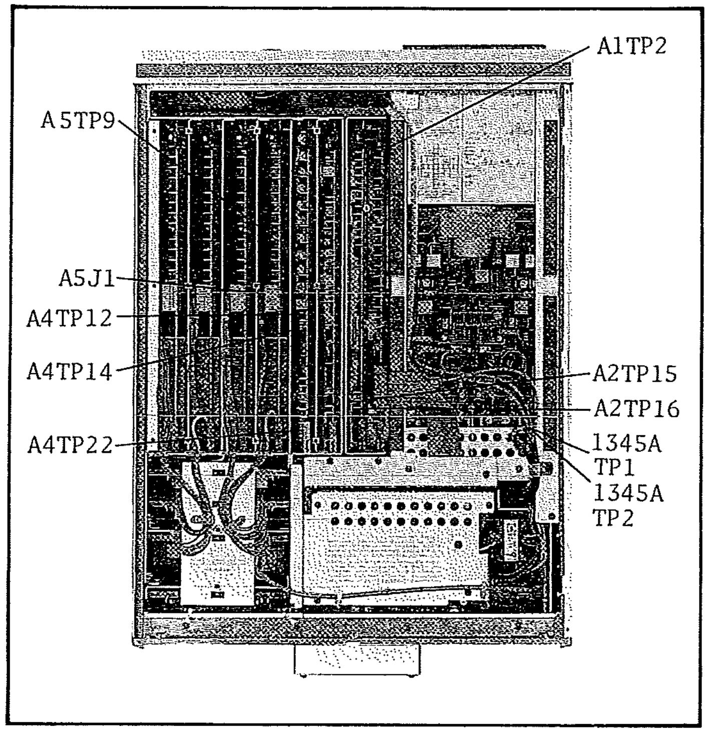


Figure 5-7. Check Point Locations.

Table 5-3. Check Points and Limits

Grounded Section			Floated Section		
Test Lead Connection		Limit	Test Lead Connection		Limit
HI input	LOW input		HI input	LOW input	
A2TP14	GND (CHASSIS)	-5V±0.25V	A4TP12	A5TP9 (CM*)	15V±0.5V
A2TP15	GND (CHASSIS)	12V±1.2V	A4TP14	A5TP9 (CM*)	-15V±0.5V
1345A TP1	GND (CHASSIS)	-15V±0.75V	A4TP22	A5TP9 (CM*)	5V±0.25V 4.7mV
1345A TP2	GND (CHASSIS)	15V±0.75V	A5J1 pin 1	A5TP9 (CM*)	130V-13V+26V
			A5J1 pin10	A5TP9 (CM*)	-130V+13V-26V

* CM: COMMON

ADJUSTMENTS

5-25. SAMPLE HOLD SWITCH AC OFFSET ADJUSTMENT

PURPOSE: This adjustment eliminates AC offset generated by A3U24 (Sample Hold Switch).

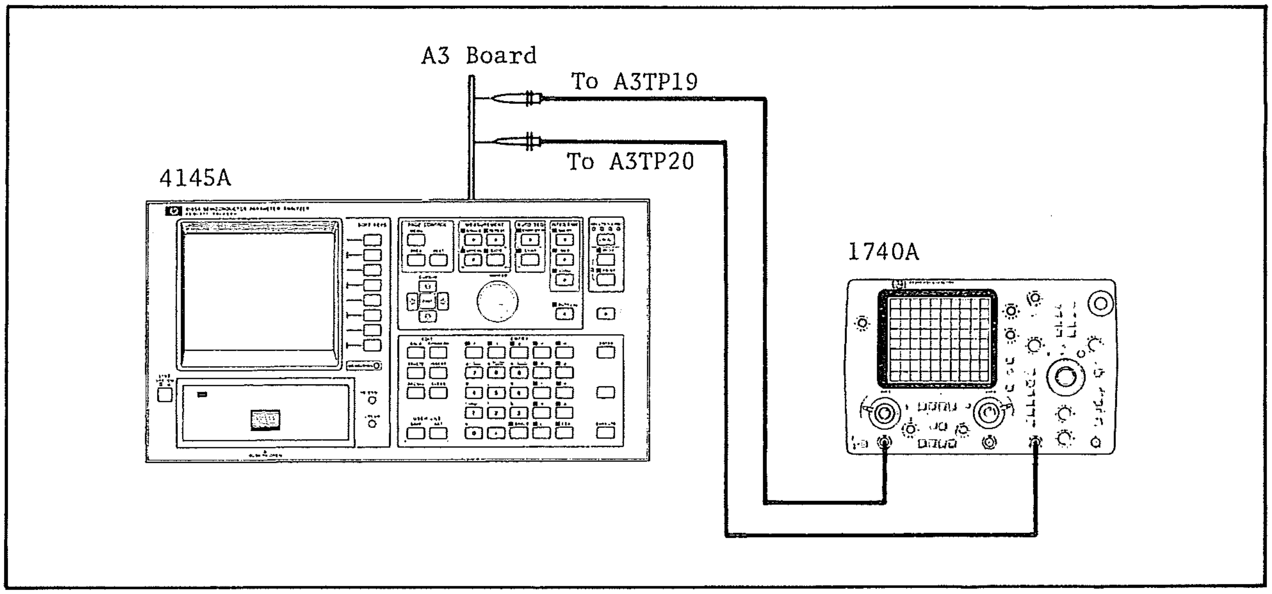


Figure 5-8. Sample Hold Switch AC Offset Adjustment Setup.

EQUIPMENT:

Oscilloscope	HP MODEL 1740A
1 : 1 Probe (2 ea)	HP MODEL 10007B
Extender Board	HP P/N 04145-66521

PROCEDURE:

1. Extend the A3 SMU Control and A-D Converter Board with the extender board (HP P/N : 04145-26521).

2. Set A3S1 (SW1) to 1001011. See Figure 5-10 for the location of A3S1.

3. Verify that A3W2 through A3W6 are set to N (Normal Mode).

4. Connect the channel A or B input to A3TP19 and the EXT TRIGGER input to A3TP20 (see Figure 5-10 for the locations). Obtain channel A or B input GND (ground) from A3TP3.

CAUTION

BE CAREFUL NOT TO TOUCH THE GND CLIP TO A3TP2 and A3TP4. ±15 VOLTS IS PRESENT AT THE TEST POINTS.

5. Set the 1740A's controls as follows:

VOLT/DIV	0.005
COUPLING	AC
TIME/DIV	0.1msec
TRIGGER	EXT
SWEEP MODE	NORM
MAGx5	ON

6. Disconnect the test fixture and cables from the 4145A, then turn on the 4145A and the 1740A.

7. Adjust A3R30 (see Figure 5-10 for the location) until the height of the pulse at A3TP19 is minimized (less than 0.5mV) as shown in Figure 5-9.

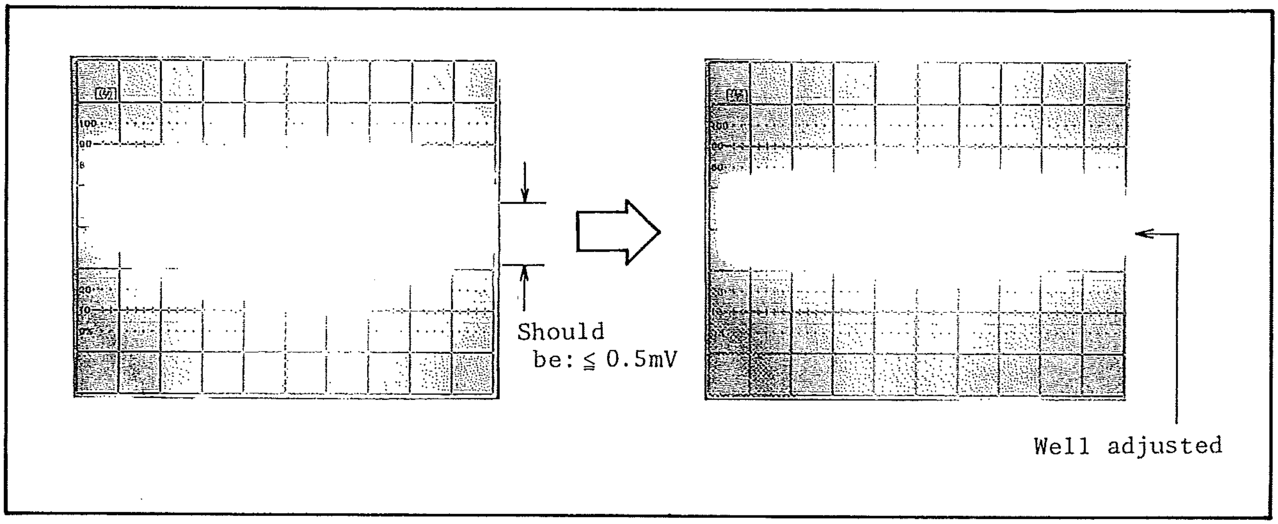


Figure 5-9. AC Offset Adjustment.

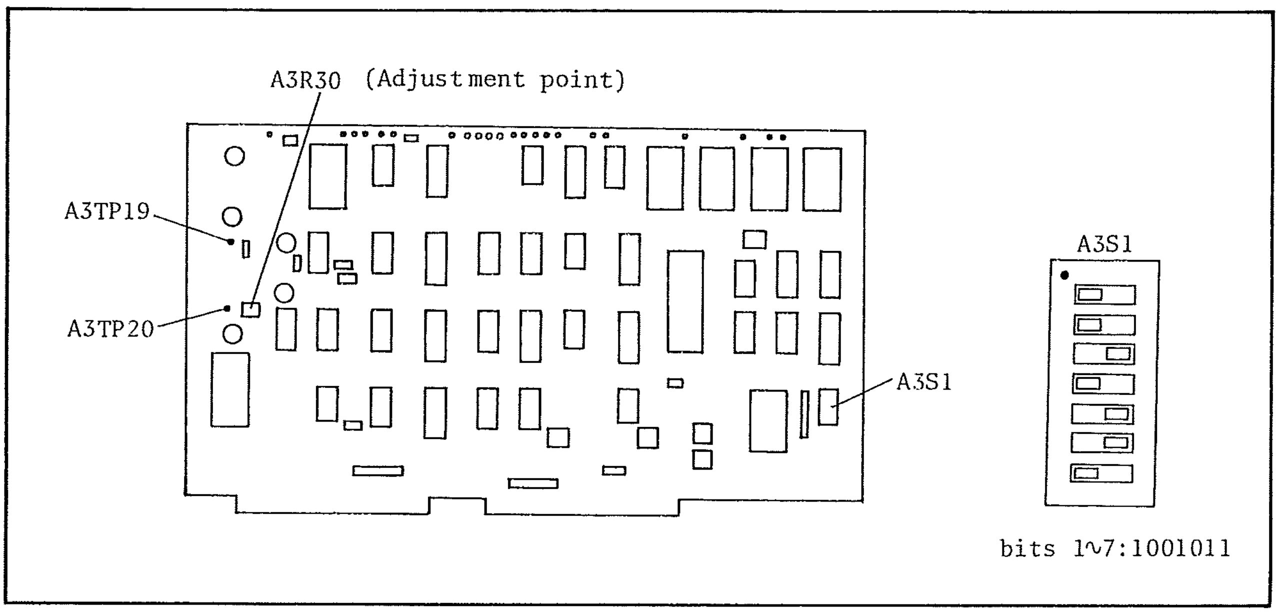


Figure 5-10. Check/Adjustment Point Locations.

5-26. DEMULTIPLEXER NOISE REJECTION ADJUSTMENT

PURPOSE: This adjustment eliminates AC offset generated by the demultiplexer (Sample Hold Switch) on the A4 board.

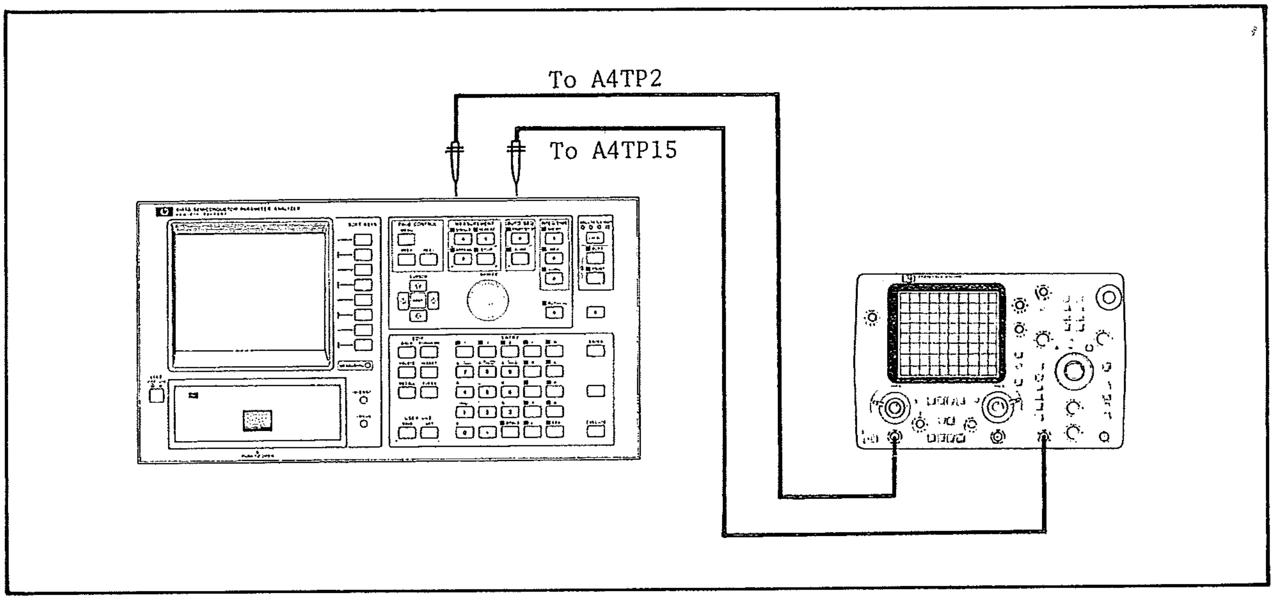


Figure 5-11. Demultiplexer Noise Rejection Adjustment Setup.

EQUIPMENT:

Oscilloscope .... HP MODEL 1740A
1 : 1 Probe (2ea) .... HP MODEL 10007B

PROCEDURE:

1. Remove the A3 SMU Control and A-D Converter Board and the A4 D-A Converter Board, and set A3S1 (SW1) to 1001011. See Figure 5-13 for the location of A3S1.

2. Verify that jumpers A3W2 through A3W6 and A4W1 (see Figure 5-13) are set to N (Normal Mode).

3. Reinstall the A3 and A4 boards.

4. Connect the channel A or B input to A4TP2 and the EXT TRIGGER input to A4TP15 (see Figure 5-13 for the locations). Obtain channel A or B input GND (ground) from A4TP13.

CAUTION

BE CAREFUL WHEN CONNECTING THE GND CLIP. ±15 VOLTS IS PRESENT AT A4TP12 AND A4TP14.

5. Set the 1740A's controls as follows :

VOLT/DIV	0.005
COUPLING	AC
TIME/DIV	0.2msec
TRIGGER	EXT
SWEEP MODE	NORM
MAGx5	ON

6. Disconnect the test fixture and cables from the 4145Aa, then turn on the 4145A and 1740A.

7. Adjust A4C1 until the height of the pulse at A4TP2 is minimized (less than 0.5mV) as shown in Figure 5-14.

8. Perform step 7 for each test point/trimmer capacitor combination listed in Table 5-4.

Table 5-4. Test Point/Trimmer Capacitor Combinations

Test Point/Trimmer Capacitor Combinations	
Test Point	Trimmer Adjusted
A4TP3	A4C2
A4TP4	A4C3
A4TP5	A4C4
A4TP6	A4C5
A4TP7	A4C6
A4TP8	A4C7
A4TP9	A4C8
A4TP10	A4C9
A4TP11	A4C10

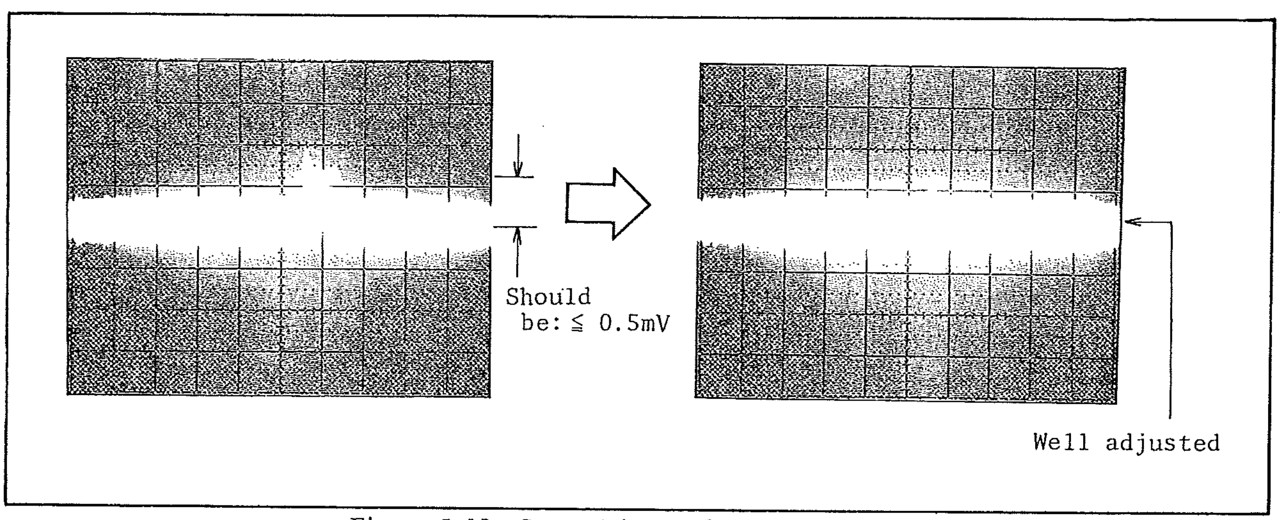


Figure 5-12. Scope Display for Adjustment.

ADJUSTMENTS

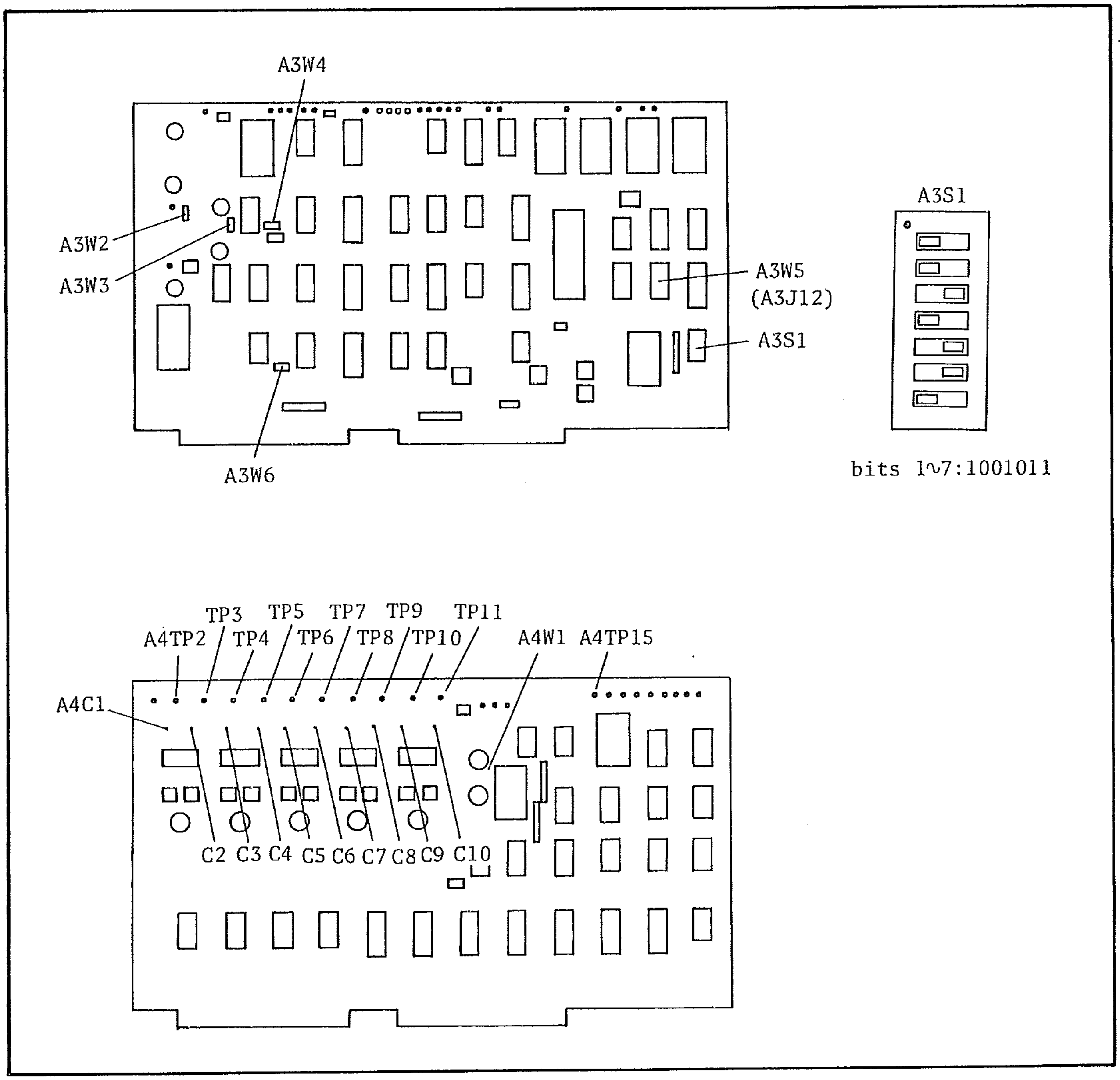


Figure 5-13. Test Point Locations.

5-27. D-A CONVERTER GAIN ADJUSTMENT

PURPOSE: This adjustment accurately sets the gain of the D-A Converter for analog output.

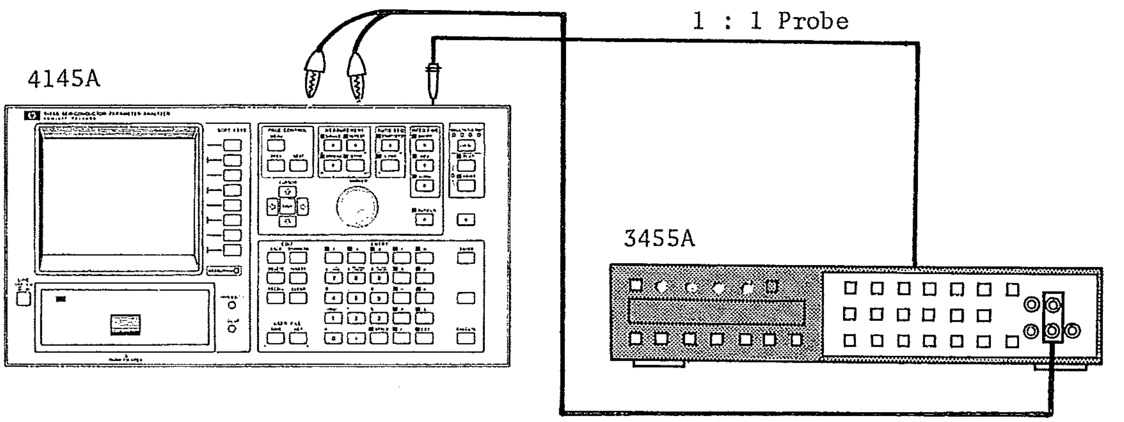


Figure 5-14. D-A Converter Gain Adjustment Setup.

EQUIPMENT:

DVM	HP MODEL 3455A*
Test Lead (alligator clips to dual banana plug)	HP MODEL 11002A
1 : 1 Probe	HP MODEL 10007B

* The 3455A must be calibrated before this adjustment.

PROCEDURE:

1. Remove the A3 SMU Control and A-D Converter Board and A4 D-A Converter Board, and set A3S1 (SW1) to 1001100. See Figure 5-15 for the location of A3S1.

2. Verify that jumpers A3W2 through A3W6 and A4W1 (see Figure 5-15 for the locations) are set to N (Normal Mode).

3. Reinstall the A3 and A4 boards.

4. Connect DVM HI input to A4TP2 (-10V), LOW input to A4TP13 (AGND : analog ground), and EXT TRIGGER input to A4TP15 (see Figure 5-11 for the locations).

CAUTION

BE CAREFUL WHEN THE LOW INPUT IS CONNECTED TO A4TP13. ±15V IS PRESENT AT A4TP12 AND A4TP14.

5. Set the 3455A's controls as follows :

FUNCTION	⎓V
RANGE	AUTO
TRIGGER	EXT

6. Disconnect the test fixture and cables from the 4145A, then turn on the 4145A and the 3455A.

7. Adjust A4R11 (see Figure 5-11 for location) until the reading on the DVM is -10.000V±0.5mV. The voltage at A4TP2 is a staircase signal. Adjust A4R11 only at the -10V step.

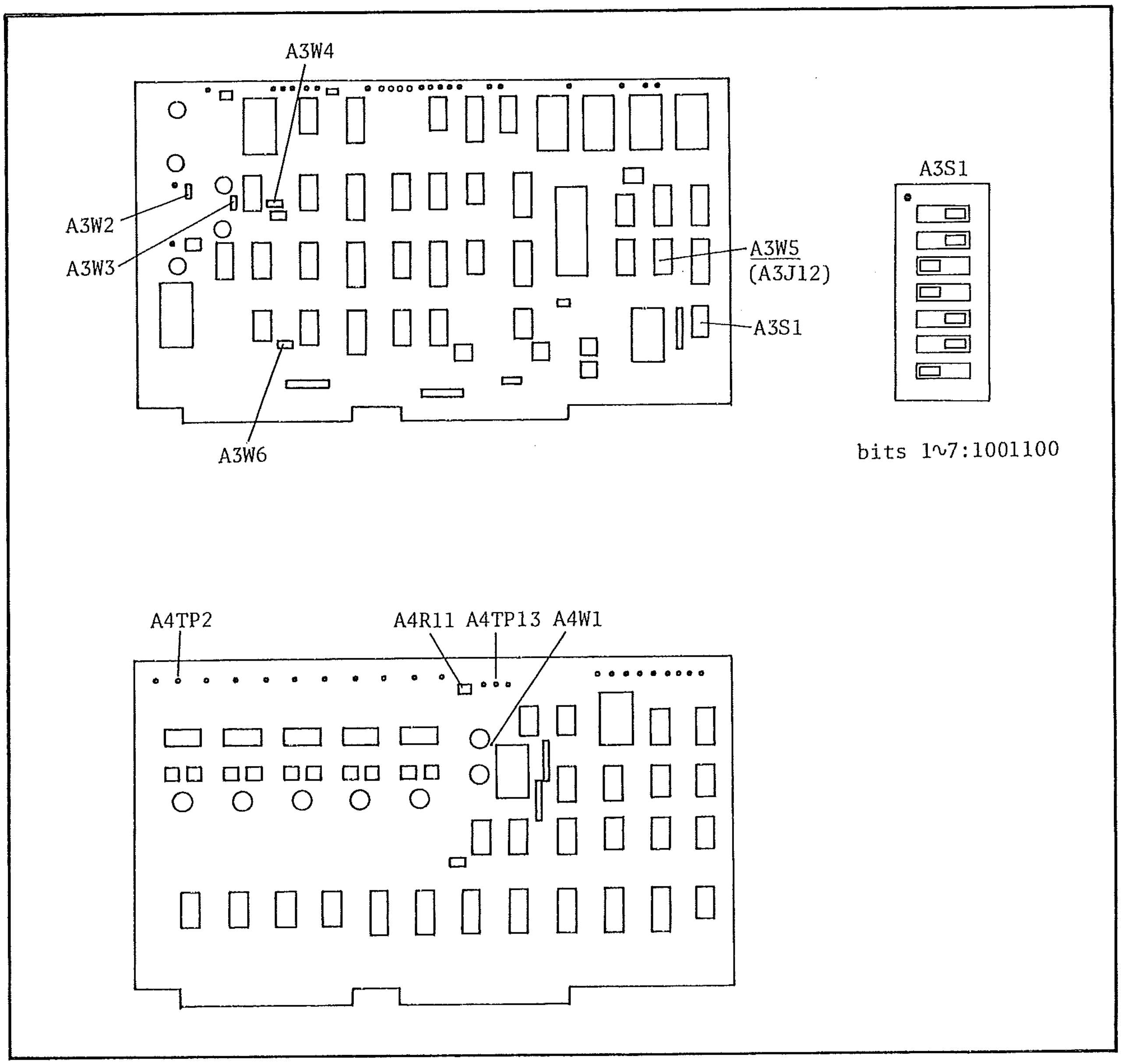


Figure 5-15. Check/Adjustment Point Locations.

5-28. A-D CONVERTER GAIN ADJUSTMENT

PURPOSE: This adjustment accurately sets the gain of the A-D converter.

1. Remove the A3 SMU Control and A-D Converter Board and the A4 D-A Converter Board, and set A3S1 (SW1) to 1001101. See Figure 5-17 for the location of A3S1.

2. Verify that jumpers A3W2 through A3W6 and A4W1 (see Figure 5-16 for the locations) are set to N (Normal Mode).

3. Reinstall the A3 and A4 boards.

4. Disconnect the test fixture and cables from the 4145A, then turn on the 4145A.

5. Adjust A3R1 (see Figure 5-17 for the location) until the LED announciator pattern indicates "pass" as shown in Figure 5-16.

RESULT	Announciators				Description
	DS1	DS2	DS3	DS4	
Pass	○	○	○	○	Adjustment is accurately set.
Fail	●	●	○	○	Gain is under-adjusted. Adjust A3R1 clockwise.ckwise.
Fail	○	○	●	●	Gain is over-adjusted. Adjust A3R1 counterclockwise.

○ : ON (blinking), ● : OFF

Figure 5-16. Results from LED Announciators.

ADJUSTMENTS

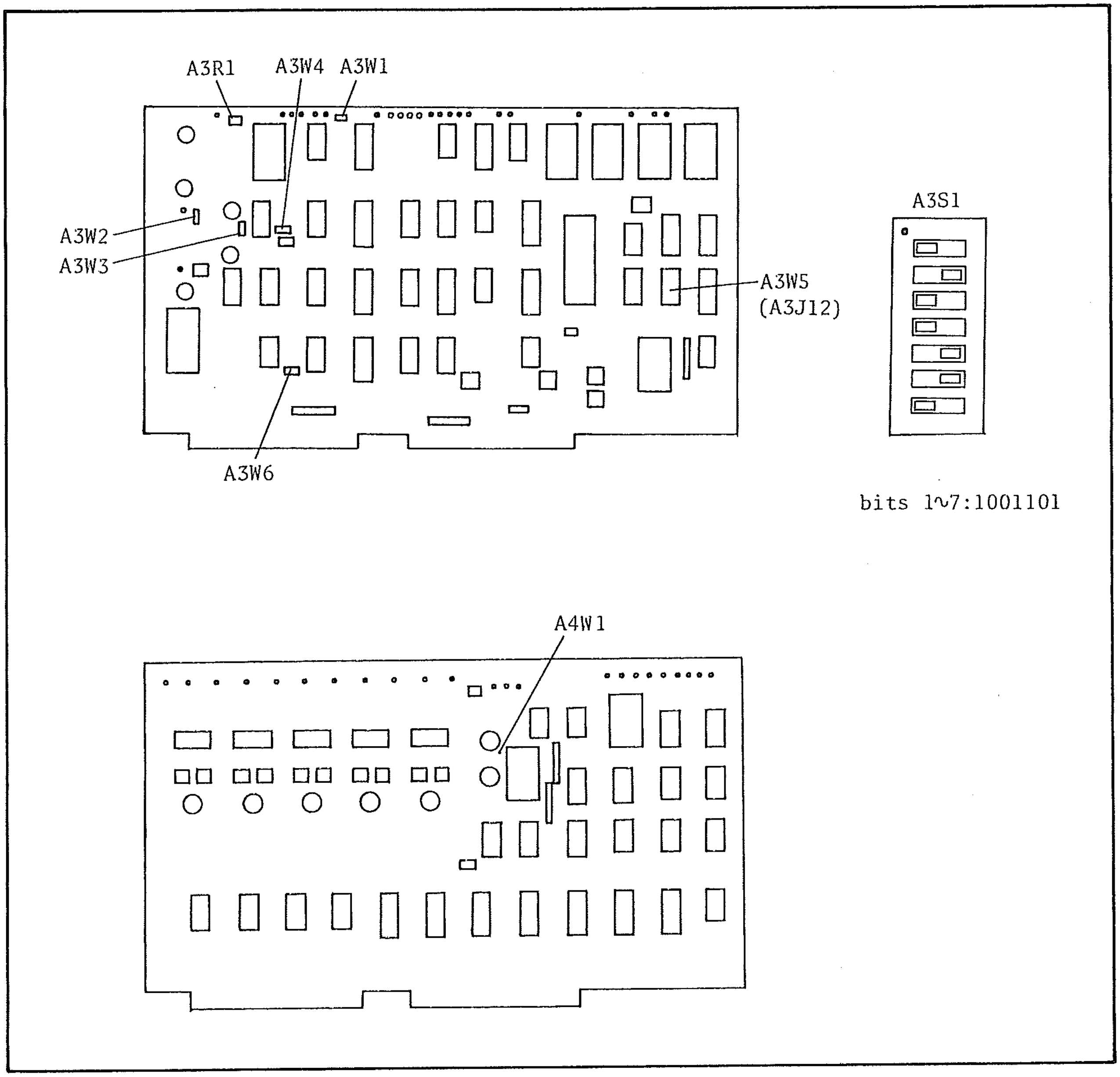


Figure 5-17. Check/Adjustment Point Locations.

5-29. VM RANGE ADJUSTMENT

PURPOSE : This adjustment accurately sets the gain of the Voltage Monitor 1 (Vm1) and Voltage Monitor 2 (Vm2).

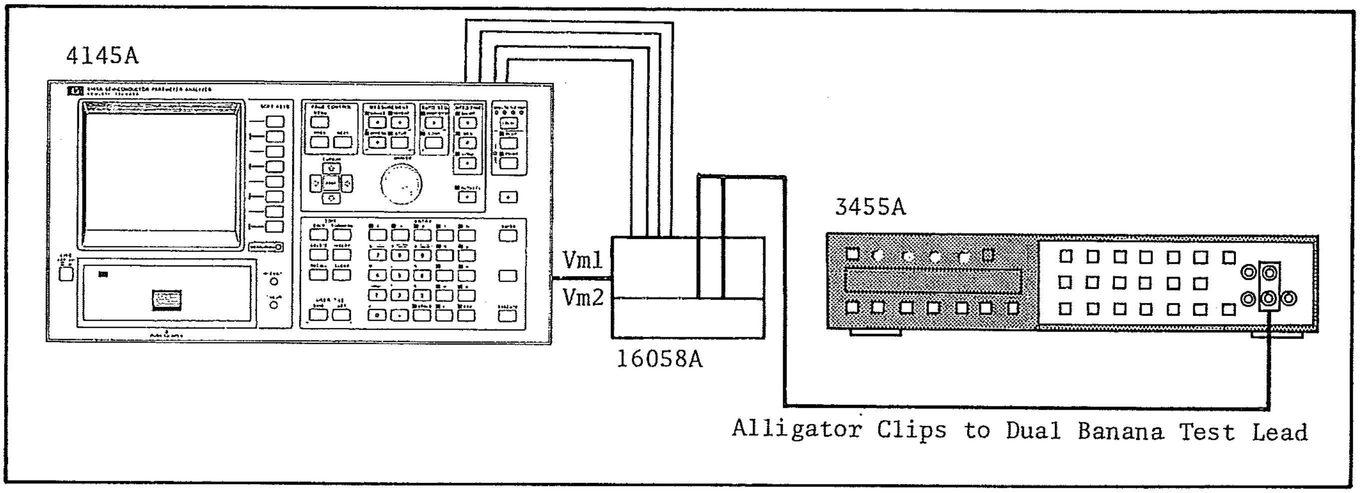


Figure 5-18. VM Range Adjustment Setup.

EQUIPMENT :

DVM .... HP MODEL 3455A
Test Fixture (with cables) .... HP MODEL 16058A
TEST Lead (alligator clips to dual banana plug) .... HP MODEL 10007B

PROCEDURE :

1. Connect the 16058A and the 4145A with the triaxial cables and the system cable (furnished with the 16058A).

2. Set the 4145A's controls as follows :

   i) On the CHANNEL DEFINITION page :

   Set up the page as shown in the figure.

[hp] *** CHANNEL DEFINITION ***

	NAME		SOURCE	
CHAN	V	I	MODE	FCTN
SMU1	V1	I1	V	CONST
SMU2	V2	I2	V	CONST
SMU3	V3	I3	V	VAR1
SMU4				
Vs 1		-----	V	
Vs 2		-----	V	
Vm 1	VM1	-----	----	----
Vm 2	VM2	-----	----	----

USER FCTN	NAME (UNIT) = EXPRESSION
1	____( )=
2	____( )=

ii) On the SOURCE SET UP page and MEAS & DISP MODE SET UP page :

Set up the pages as shown in the figure below :

[hp] ****** SOURCE SET UP ******

	VAR1	VAR2
NAME	V3	
SWEEP MODE	LINEAR	LINEAR
START	.0000V	
STOP	1.0000V	------
STEP	1.0000V	
NO. OF STEP	2	
COMPLIANCE	100.0mA	

CONSTANT	SOURCE	COMPLIANCE
V1 V	20.000V	100.0mA
V2 V	20.000V	100.0mA

[hp] ** MEAS & DISP MODE SET UP **

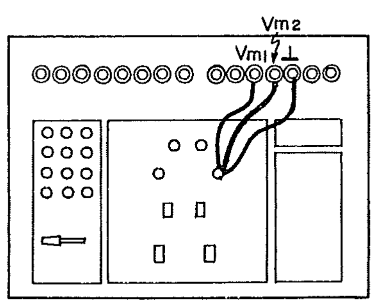
MEASUREMENT MODE: SWEEP

DISPLAY MODE: LIST

NAMES	VM1
	VM2

iii) INTEG TIME LONG

3. Connect the cables between the Personality Board and socket board as shown below. Use any of the socket boards and miniature banana-pin plug cables* (furnished with the 16058A).



4. Set the 3455A's controls as follows :

FUNCTION .... ═ V
RANGE .... AUTO
TRIGGER .... INTERNAL

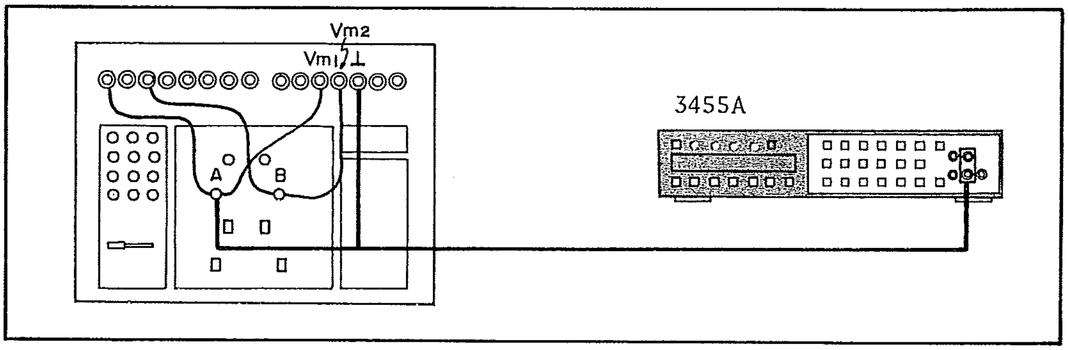
5. Perform measurement by pressing the REPEAT key.

ADJUSTMENTS

6. Record the readings on the 4145A for offset value $VM1_o$ (for Vm1) and $VM2_o$ (for Vm2).

7. End measurement by pressing the STOP key.

8. Change the cable connection to monitor the voltage value between point A and the ground terminal with the 3455A as shown below. Then press the REPEAT key.



9. Adjust A16R4 (see Figure 5-19 for the location) for Vm1 gain until VM1 (value displayed on the 4145A) and Vdvm1 (reading on the 3455A) satisfy the following inequality. Then press the STOP key.

$$VM1-5/2VM1_o-10 \text{ counts} \leq Vdvm1 \leq VM1-5/2VM1_o+10 \text{ counts}$$

10. Change the 3455A's connection to point B, then press the REPEAT key.

11. Adjust A16R104 (see Figure 5-19 for the location) for Vm2 gain until VM2 (value displayed on the 4145A) and Vdvm2 (reading on the 3455A) satisfy the following inequality. Then press the STOP key.

$$VM2-5/2VM2_o-10 \text{ counts} \leq Vdvm2 \leq VM2-5/2VM2_o+10 \text{ counts}$$

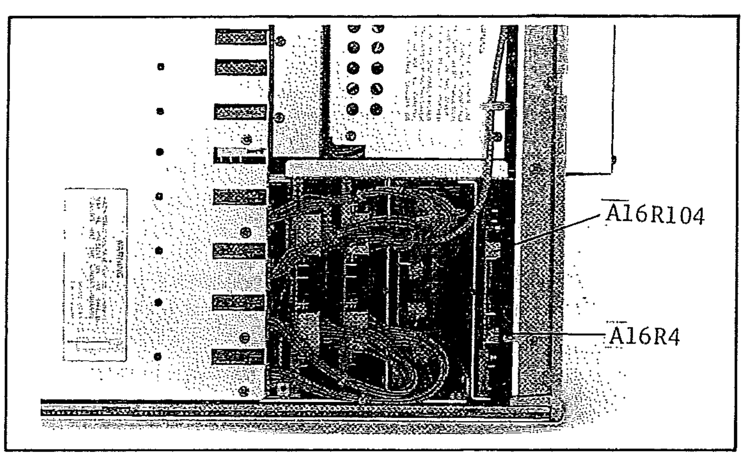


Figure 5-19. Adjustment Point Locations.

5-30. MASS STORAGE UNIT TEST

5-31. The Mass Storage Unit (MSU) consists of flexible-disc drive (FDD) and a disc (software disc). The MSU Test includes disc check and flexible-disc drive checks and adjustments described starting in paragraph 5-43.

5-32. FLEXIBLE-DISC DRIVE ACCESS

5-33. To facilitate throughgoing adjustment of the flexible-disc drive, the drive unit must be pulled out (removed but not electrically disconnected) from the 4145A.

1. Stand the 4145A on its side, and remove the bottom cover.

2. Loosen and remove the four retaining screws from the flexible-disc drive.

3. Carefully remove the drive unit from the 4145A through the front panel. Leave all cables connected to the drive unit.

4. Place the drive unit on a clean work surface as shown in Figure 5-20.

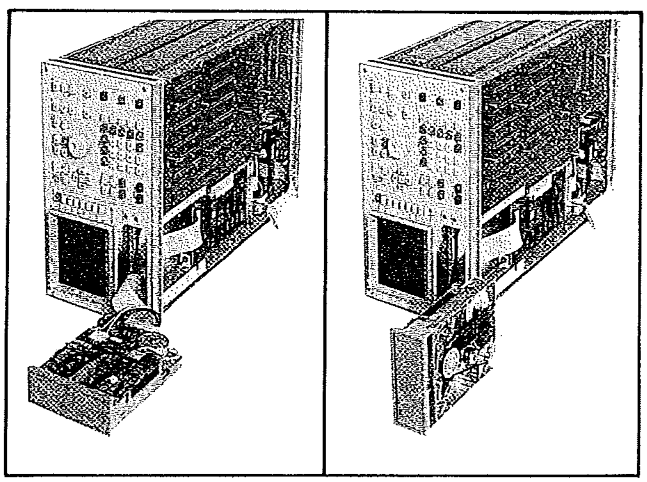


Figure 5-20. Flexible-disc Drive Access.

5-34. DISC CHECK

5-35. A visual check of the disc should be made periodically. When contamination, wear, bends, or creases are observed, and the 4145A is experiencing an MSU trouble, try the MSU operation again using a new disc. If the anomaly persists, perform the SMU tests described starting in paragraph 5-43. A good rule of thums is to use a new disc instead of the suspicious disc even if the disc is visually perfect. For troubleshooting the MSU, see to Section VIII in this manual and contact the nearest Hewlett-Packard Sales Office.

5-36. FLEXIBLE-DISC DRIVE CHECKS AND ADJUSTMENTS

5-37. There are eight flexible-disc drive checks and adjustments :

(1) MSU Read Test (paragraph 5-43)

(2) MSU Write Test (paragraph 5-46)

(3) Drive Belt Tension Check and Adjustment (paragraph 5-52)

(4) Index Timing Check and Adjustment (paragraph 5-53)

(5) Track Alignment Check and Adjustment (paragraph 5-54)

(6) Track Zero Switch Check and Adjustment (paragraph 5-55)

(7) Jitter Check and Adjustment (paragraph 5-56)

(8) Index Detector Alignment Check and Adjustment (paragraph 5-57)

To perform checks and adjustments 1 through 8, except 3, the 4145A must be set to MSU DIAGNOSTICS Mode. See paragraph 5-40 for details.

5-38. SURE FLEXIBLE-DISC DRIVE CHECKS AND ADJUSTMENTS

5-39. Be aware of the following cautions for your own protection and to avoid damage to the flexible-disc drive.

WARNING

MOST OF THE FLEXIBLE-DISC DRIVE CHECKS AND ADJUSTMENTS DESCRIBED HEREIN ARE PERFORMED WITH POWER SUPPLIED TO THE INSTRUMENT. SUCH ADJUSTMENTS MUST BE PERFORMED ONLY BY QUALIFIED SERVICE PERSONNEL.

5-40. MSU DIAGNOSTICS MODE

5-41. When checks and adjustments of the flexible-disc drive (FDD) are performed, the 4145A must be set to MSU (Mass Storage Unit) DIAGNOSTICS Mode. The mode is provided to perform checks and adjustments of the FDD without using special electronic tools. When the 4145A is in MSU DIAGNOSTICS mode, the drive motor of the FDD goes on automatically. MSU DIAGNOSTICS Mode is used for the MSU Read Test, the MSU Write Test, and the MSU EXERCISER listed in Table 5-5.

5-42. Set the 4145A to the MSU

DIAGNOSTICS mode is as follows:

1. Turn off the 4145A, and remove the top cover.

2. Remove A2U14 and install the MSU Test ROM (A1U8; HP P/N 04145-85018) in its place. The MSU Test ROM is provided on the A1 Graphic Display Control Board. See Figure 5-21 for A2U14 and MSU Test ROM locations.

3. Set A2S1 to 1010011. See Figure 5-21 for the A2S1 setting and its location. The seven bits of A2S1 are initially set to all ones (1111111). After checks and adjustments of the FDD have been performed, A2S1 must be set to the initial setting.

Table 5-5. MSU DIAGNOSTICS Mode

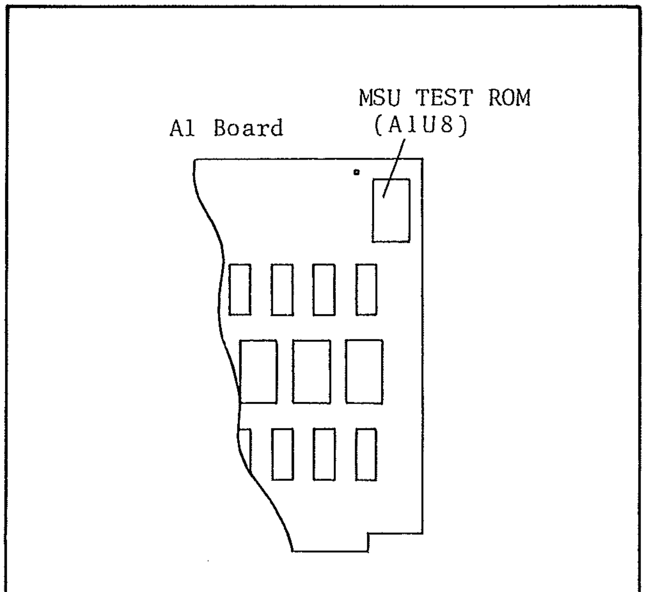
Mode	Description	Related Paragraph
MSU READ TEST	The MSU Read Test can be performed when the WRITE TEST softkey is pressed.	5-43
MSU WRITE TEST	The MSU Write Test can be performed when the WRITE TEST softkey is pressed.	5-46
MSU EXERCISER	The following checks and adjustments of the FDD can be performed:	5-49
	1. Index Timing Check And Adjustment	5-53
	2. Track Alignment Check And Adjustment	5-54
	3. Track Zero Switch Check And Adjustment	5-55
	4. Jitter Check And Adjustment	5-56
	5. Index Detector Alignment Check And Adjustment	5-57

4. Put the 4145A on its side, and remove the bottom cover.

5. Set A9W3 (see Figure 5-21 for location) from T/N (test/normal position) to E (EXERCISER).

6. Remove the HP-IB cable connector connected to the A9 HP-IB and MSU Control Board from the A9 board.

7. Disconnect the test fixture from the 4145A, then turn on the 4145A. The 4145A will go into MSU DIAGNOSTICS mode and display the MSU DIAGNOSTICS page shown in Figure 5-22.



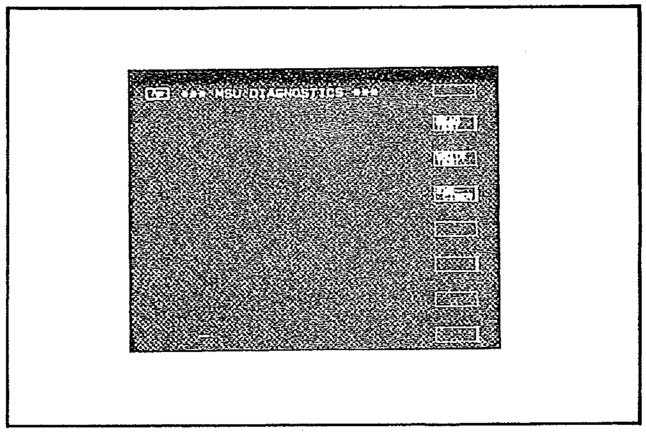


Figure 5-22. CRT Display of MSU DIAGNOSTICS Page.

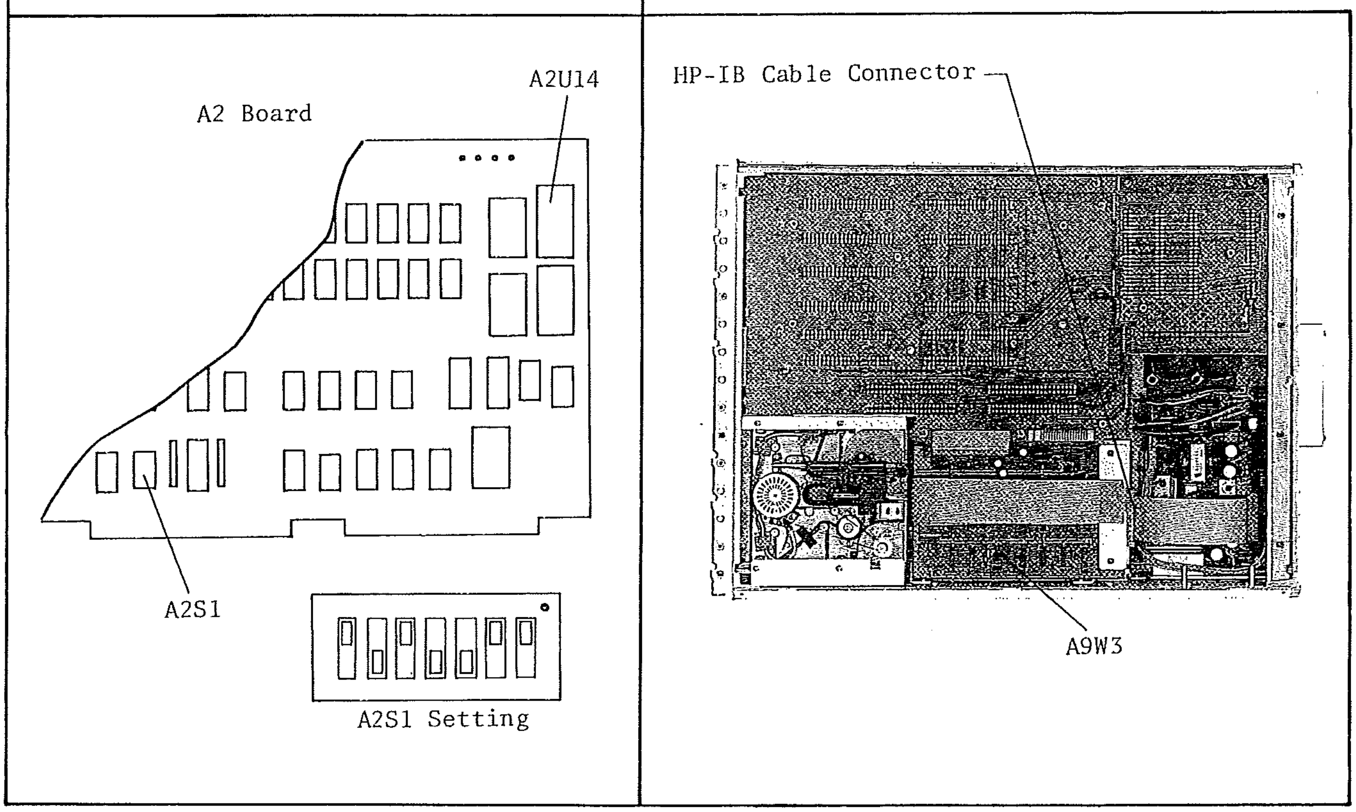
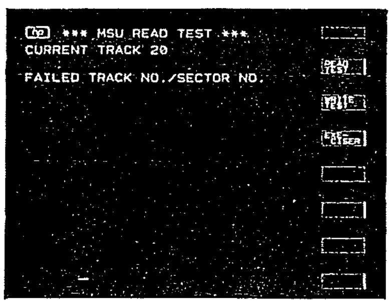


Figure 5-21. Component Locations for MSU DIAGNOSTICS Mode setting.

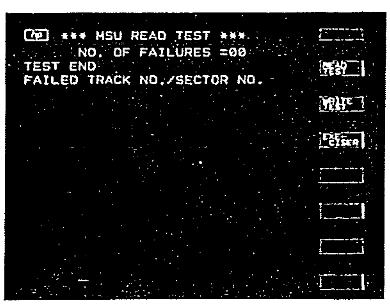
5-43. MSU READ TEST

5-44. The MSU Read Test is provided for the flexible-disc drive (FDD) read capability check. After the READ TEST softkey has been pressed while viewing the MSU DIAGNOSTICS page, the 4145A displays the screen shown in Figure 5-23-1, and the read test is performed automatically.

5-45. The disc surface is divided into forty tracks, and each track is divided into nine sectors (one sector equals 256 bytes) or 360 sectors total on a single disc. In the MSU Read Test all forty tracks are checked by track and by sector. The test results are displayed on the CRT as shown in Figure 5-23. For the read test, the software disc supplied with 4145A can be used.



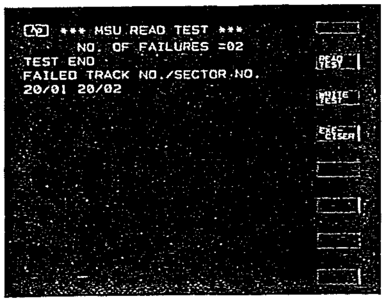
(1) When the READ TEST softkey is pressed, this display is shown. The display shows the track number where the read test is being performed. When an error is detected, the failed track number and the failed sector number are displayed.



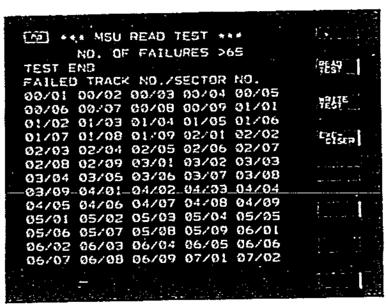
(2) When no error is detected, this display is shown, and the read test ends automatically.

Figure 5-23. CRT Display of MSU Read Test.

CHECKS AND ADJUSTMENTS



(3) In this case, two errors were detected on sectors 01 and 02 of track 20. If only a few errors are detected, perform the read test again with another disc. If no errors are detected in the second test, the disc used in the first test is probably defective.



(4) If more than sixty-five errors are detected, the read test ends automatically even if not completed. After the display at left has been shown, perform the read test again with another disc. If the results are still the same, the flexible-disc drive is probably defective.

Figure 5-23. CRT Display of MSU Read Test (Cont'd).

Note

If the results of the MSU Read Test are as shown in Figure 5-23-(4) with every disc, the flexible-disc drive is probably at fault. The flexible-disc drive checks and adjustments must be performed, and the troubleshooting procedures described in Section VIII may also be necessary.

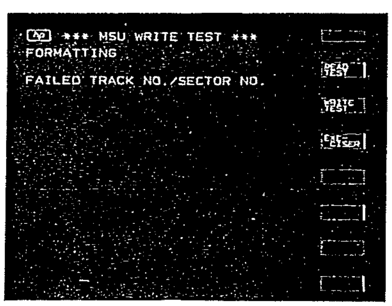
5-46. MSU WRITE TEST

5-47. The MSU Write Test is provided for the flexible-disc drive (FDD) write capability check. After the WRITE TEST softkey has been pressed while viewing the MSU DIAGNOSTICS page, the 4145A goes into test status, and the MSU Write Test is performed automatically.

5-48. In the MSU Write Test the following procedure is performed automatically in the order below :

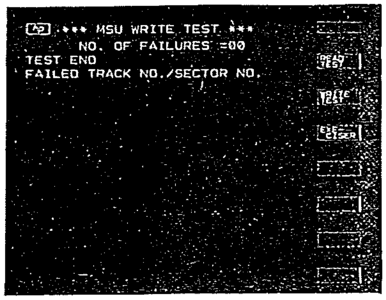
1. Re-format the entire disc surface.
2. Write pattern "$1A_H$" on all 360 sectors.
3. Read the data "$1A_H$" and verify that the data has been correctly written. If any errors are detected, display the error message shown in Figure 5-24-(3).
4. Write pattern "$E5_H$" on all 360 sectors.
5. Read and verify the data "$E5_H$". If any errors are detected, display the error message shown in Figure 5-24-(3).

The software discs furnished with the 4145A must not be used for the MSU Write Test, because the 4145A's operation software and other important programs and data are lost after the test has been completed. The blank disc, incuded in FDD Service Kit (HP P/N : 04145-65100), is recommended for use.

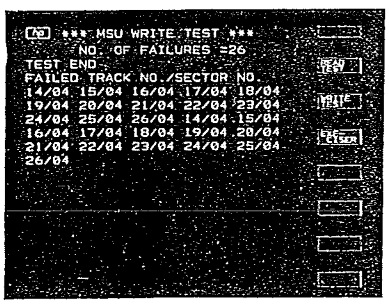


(1) When the WRITE TEST softkey is pressed, this display is shown. The write test is performed in the order described in paragraph 5-48.

Figure 5-24. CRT Display of MSU Write Test.



(2) If the write test ends without failures, this display is shown.



(3) In this case, thirteen errors were detected for each of patterns "1A$_H$" and "E5$_H$". Perform the write test again with another disc. If no errors are detected in the second test, the disc used in the first test is probably defective.

Figure 5-24. CRT Display of MSU Write Test (Cont'd).

Note

The MSU Write Test ends automatically if more than sixty-five failures are detected. Perform the write test again using another disc. If the same results are obtained, the flexible-disc drive checks and adjustments must be performed, and the troubleshooting procedures described in Section VIII may also be necessary.

5-49. MSU EXERCISER

5-50. The 4145A goes into the MSU EXERCISER when the EXER- CISER softkey is pressed while viewing the MSU DIAGNOSTICS page, and the MSU EXERCISER page is displayed as shown in Figure 5-25. The flexible-disc drive (FDD) is in the head load status during the MSU EXERCISER if a disc has been inserted into the FDD. The MSU EXERCISER is provided for the checks and adjustments listed in Table 5-5.

5-51. Explanations of the three messages shown on the CRT and the seven softkey prompts (TRACK 00 , STEP IN , STEP OUT , ALT 0-6 , WRITE 1f , WRITE 2f , and INDEX TIMING) are given in Tables 5-6 and 5-7.

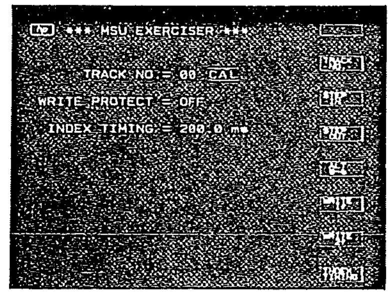


Figure 5-25. CRT Display of MSU EXERCISER Page.

Table 5-6. Messages on MSU EXERCISER Page

MESSAGE	DESCRIPTION
TRACK NO. = nn CAL*	Shows the track number in decimal where the Read/Write head is currently located. When "TRACK NO. = -- UNCAL*" is displayed, the head must be stepped to track 00 using the TRACK 00 softkey because it is either outside track 00 or inside track 39.
WRITE PROTECT = xx	Shows whether a disc is write-protected or -unprotected. If the disc is write-protected, "WRITE PROTECT = ON" will be shown. "WRITE PROTECT = OFF" will be shown otherwise.
INDEX TIMING = nnn.n ms	Shows the index timing (disc speed) in milliseconds when the INDEX TIMING softkey is pressed.

* Either "CAL" or "UNCAL" is always displayed along with the track number on the TRACK NO. message line. CAL means that the Read/Write head location is in calibrated status, while UNCAL means that the head is in uncalibrated status. UNCAL is displayed when the head steps out of track 00 or inside track 39. In the calibrated status the displayed track number is the same as the track number where the head is actually located. In uncalibrated status, there is no guarantee of the truth of the displayed track number. To recover from the uncalibrated status, press the TRACK 00 softkey described in Table 5-7.

CHECKS AND ADJUSTMENTS

Table 5-7. MSU EXERCISER Softkey Prompts

SOFT KEY	DESCRIPTION
TRACK 00	Moves the Read/Write head to track 00. When "UNCAL" is displayed on the TRACK NO. message line, press this key to recover from uncalibrated status. The 4145A then automatically detects the index timing on track 00 to display the detected value on the CRT.
STEP IN	Steps the Read/Write head towards track 39 (inward on the disc). The head moves one track every time the key is pressed.
STEP OUT	Steps the Read/Write head towards the lower track (outwards on the disc). The head moves one track every time the key is pressed.
ALT 0 -6	Sets the FDD into Alternate Movement. In Alternate Movement, the Read/Write head alternately moves between track 00 and track 06. To escape from Alternate Movement, press the key again.
WRITE 1f	Data "1f" is written once on the whole track specified when this key is pressed. On the 4145A, data "1f" means data "00_H".
WRITE 2f	Data "2f" is written once on the whole track specified when this key is pressed. On the 4145A, data "2f" means data "FF_H".
INDEX TIMING	Displays the index timing of the FDD with 100μsec resolution when this key is pressed. To stop detecting the speed, press the key again.

5-52. DRIVE BELT TENSION CHECK AND ADJUSTMENT

PURPOSE: This check and adjustment accurately sets the drive belt tension of the flexible-disc drive (FDD) for the optimum read/write capability.

EQUIPMENT:

Tension Gauge* .... HP P/N 04145-65104

* included in the FDD Service Kit (HP P/N : 04145-65100)

PROCEDURE:

1. Remove the FDD from the 4145A, and disconnect the two connectors, DC power supply cable connector, and flat cable connector from the FDD.

2. Carefully put the FDD on its top side, and set the tension gauge as shown in Figure 5-26.

3. Verify that the reading on the gauge is within the limit (76 grams to 82 grams) when the dial gauge is pushed to the gauge stopper. If out of the limit, perform steps 4 through 6.

4. Slightly loosen the two drive motor retaining screws.

5. Adjust the belt tension until the reading on the gauge is within 80 grams to 82 grams while moving the drive motor position.

6. Tighten the drive motor retaining screws and apply a small amount of glue.

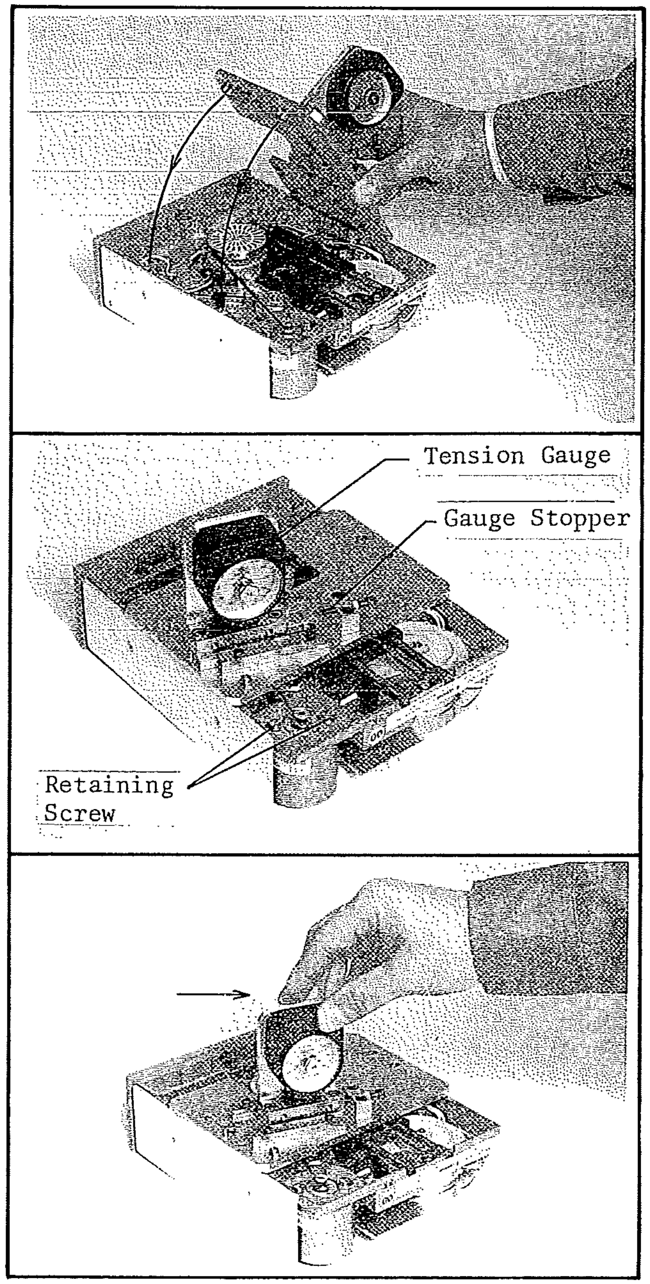


Figure 5-26. Drive Belt Tension Check and Adjustment Setup.

5-53. INDEX TIMING CHECK AND ADJUSTMENT

PURPOSE: This check and adjustment correctly sets the index timing (drive motor rotational speed) of the flexible-disc drive (FDD) for correct sector selection.

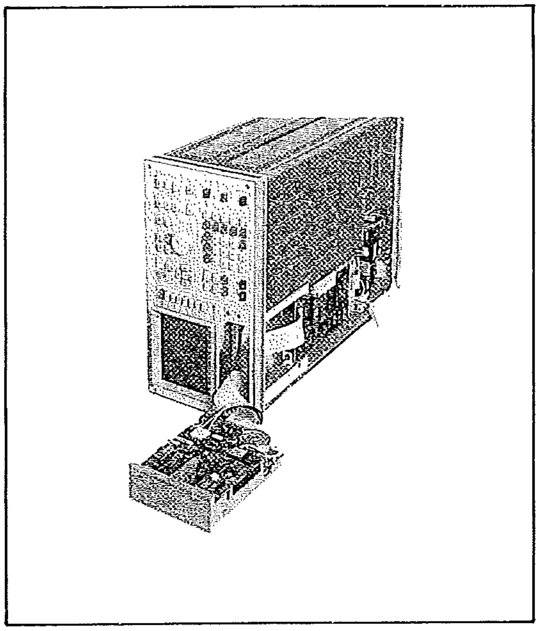


Figure 5-27. Index Timing Checks and Adjustment.

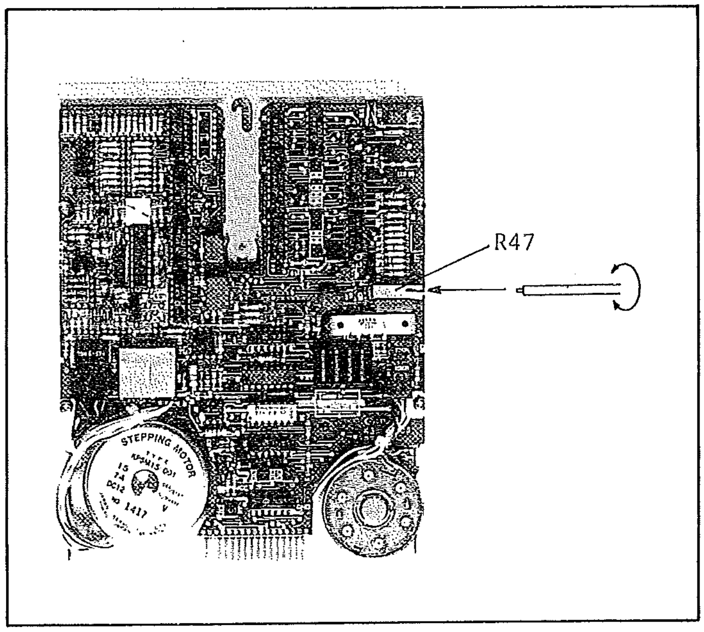


Figure 5-28. R47 Location.

EQUIPMENT:

FDD Service Kit .... HP P/N 04145-65100

PROCEDURE:

1. Turn off the 4145A, and set it to MSU DIAGNOSTICS Mode.
2. Insert a blank disc (included in the FDD Service Kit) into the FDD, and turn on the 4145A to diplay the MSU DIAGNOSTICS page.
3. Press the EXER- CISER softkey so that the 4145A goes into the MSU EXERCISER.
4. Step the Read/Write head to track 16 by pressing the STEP IN softkey.
5. Press the INDEX TIMING softkey to monitor the index timing of the FDD. Perform step 6 if the index timing is not within 200±5msec.
6. Adjust R47 (see Figure 5-28 for the location) until the index timing is within 200±1msec, monitoring the timing on the CRT. Use an insulated screwdriver.

5-54. TRACK ALIGNMENT CHECK AND ADJUSTMENT

PURPOSE: This check and adjustment verifies and correctly sets track alignment in order to eliminate errors when accessing a specified track.

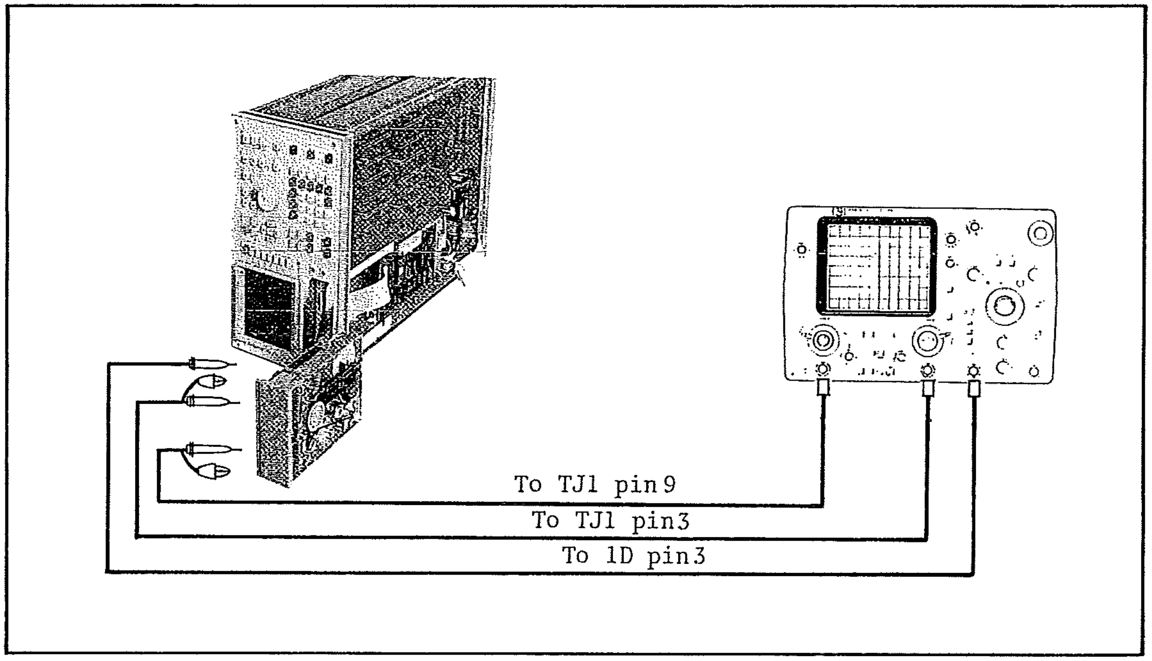


Figure 5-29. Track Alignment Check and Adjustment.

EQUIPMENT:

Oscilloscope	HP MODEL 1740A
10 : 1 Divider Probe (2ea)	HP MODEL 10040A
1 : 1 Probe	HP MODEL 10007B
FDD Service Kit	HP P/N 04145-65100

PROCEDURE:

1. Connect channel A input to TJ1 pin 9 and channel B input to TJ1 pin 7 (see Figure 5-31 for the locations) on the flexible-disc drive (FDD) PC board using 10 : 1 divider probes.

2. Obtain the external trigger from 1D pin 3 (see Figure 5-31 for location) using a 1 : 1 probe.

3. Set the 4145A to the MSU DIAGNOSTICS Mode, but do not turn on the 4145A.

CHECKS AND ADJUSTMENTS

4. Set the 1740A's controls as follows :

VOLT/DIV	channel A 0.02	(uncalibrated)
	channel B 0.02	(uncalibrated)
COUPLING	channel A AC	
	channel B AC	(inverted)
DISPLAY	A+B	
TIME/DIV	10msec	
TRIGGER	EXT	
POS/NEG.	NEG.	
SWEEP MODE	NORM	
SWEEP VERNIER	ON	

5. Insert the CE disc (included in the FDD Service Kit) into the FDD, then turn on the 4145A and the 1740A.

6. Press the EXER- CISER softkey to set the 4145A to the MSU EXERCISER.

7. Step the Read/Write head to track 16, using the STEP IN softkey.

8. Adjust the MAIN TIME/DIV knob and SWEEP VERNIER (of the 1740A) till at least four sets of bursts are displayed as shown in Figure 5-30-(1).

9. Adjust the amplitude of the first orientation burst to six scale divisions with CAL VERNIER as shown in Figure 5-30-(2).

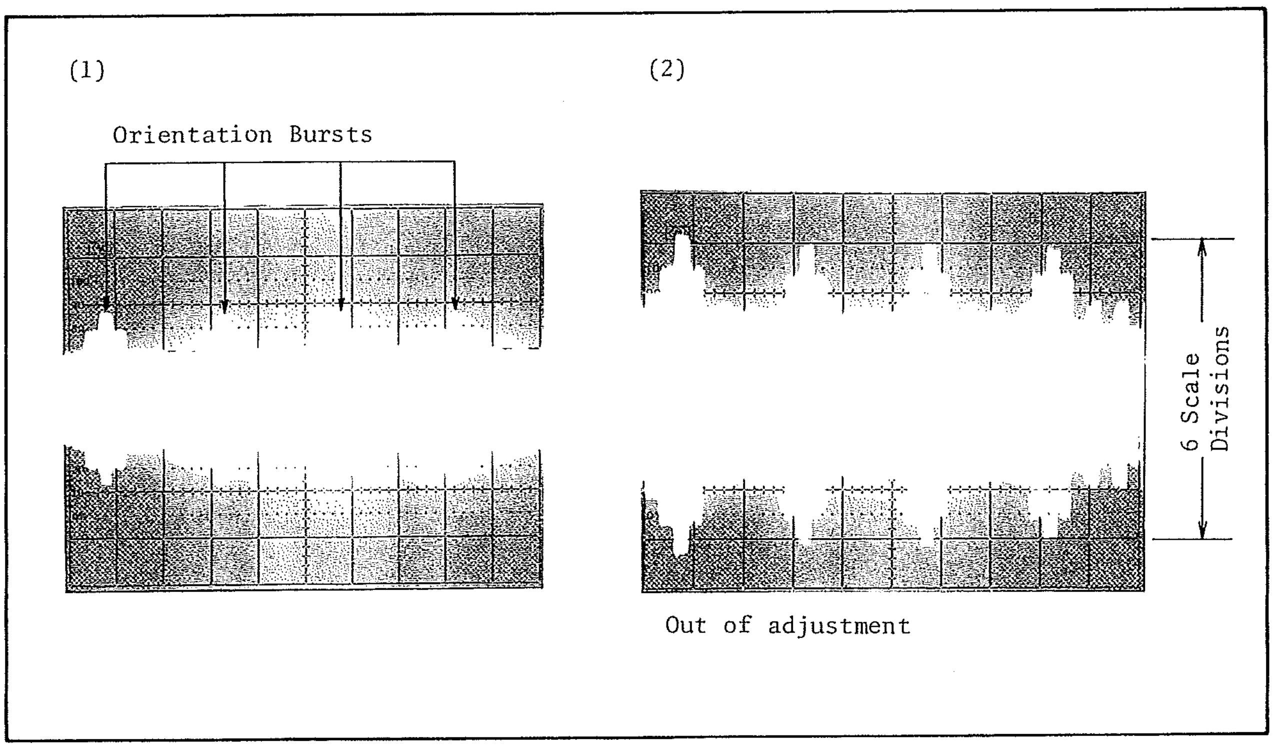


Figure 5-30. Scope Display of Bursts.

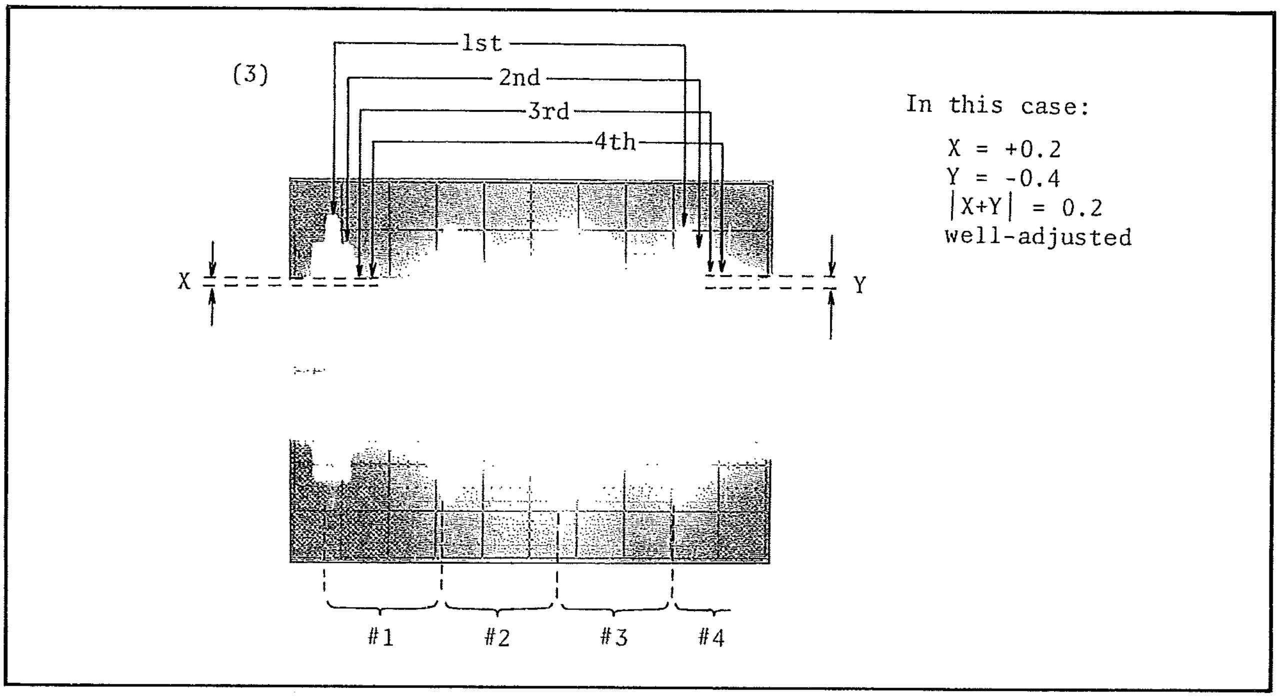


Figure 5-30. Scope Display of Bursts (Cont'd).

10. Read values of X and Y, and check whether they satisfy the following inequality:

$$|X+Y| \leqq 1.5 \text{ (scale divisions)} \quad \ldots\ldots\ 5.1$$

If the inequality is satisfied, steps 11 through 13 are not necessary.

Note

Values X and Y are the difference between the third burst and the fourth burst. The polarity of X and Y is positive if the third burst is higher than the fourth one. Otherwise, it is negative. See Figure 5-30-(3) for a pictorial explanation of X and Y.

11. Loosen the two retaining screws of the stepper motor (see Figure 5-31 for the location) and rotate it gradually until the orientation bursts reach their maximum amplitude. Then perform step 9.

12. Carefully rotate the stepper motor until X and Y satisfy the following inequality, or till both are zero.

$$|X+Y| \leqq 0.3 \text{ (scale divisions)} \quad \ldots\ldots\ 5.2$$

See Figure 5-30-(3) for details.

13. Tighten the retaining screws and apply a small amount of glue.

Note

After Track Alignment Adjustment, Track Zero Switch Check and Adjustment must be performed.

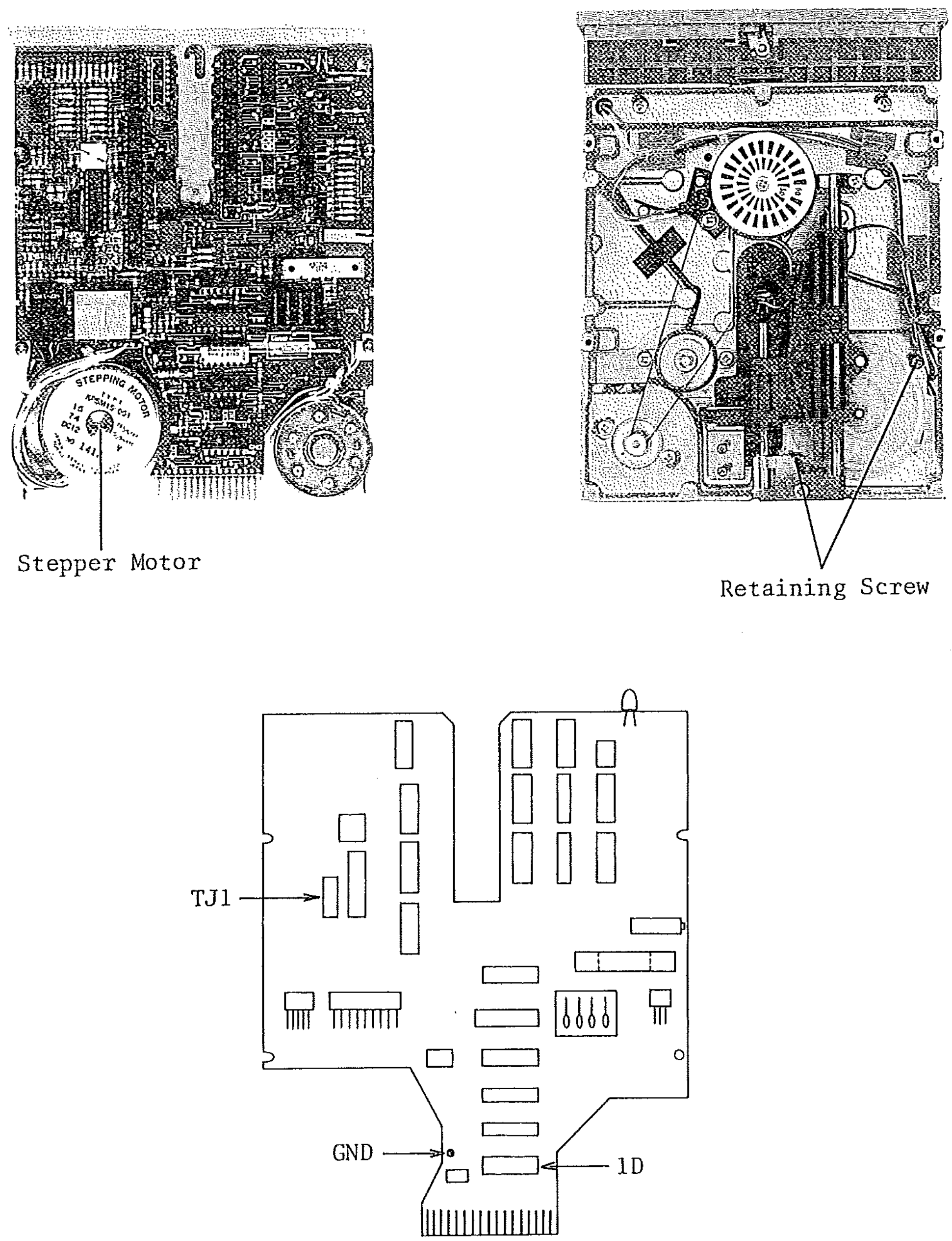


Figure 5-31. Check/Adjustment Point Locations.

5-55. TRCK ZERO SWITCH CHECK AND ADJUSTMENT

PURPOSE: This check and adjustment verifies that the track zero switch works properly and correctly sets the switching timing.

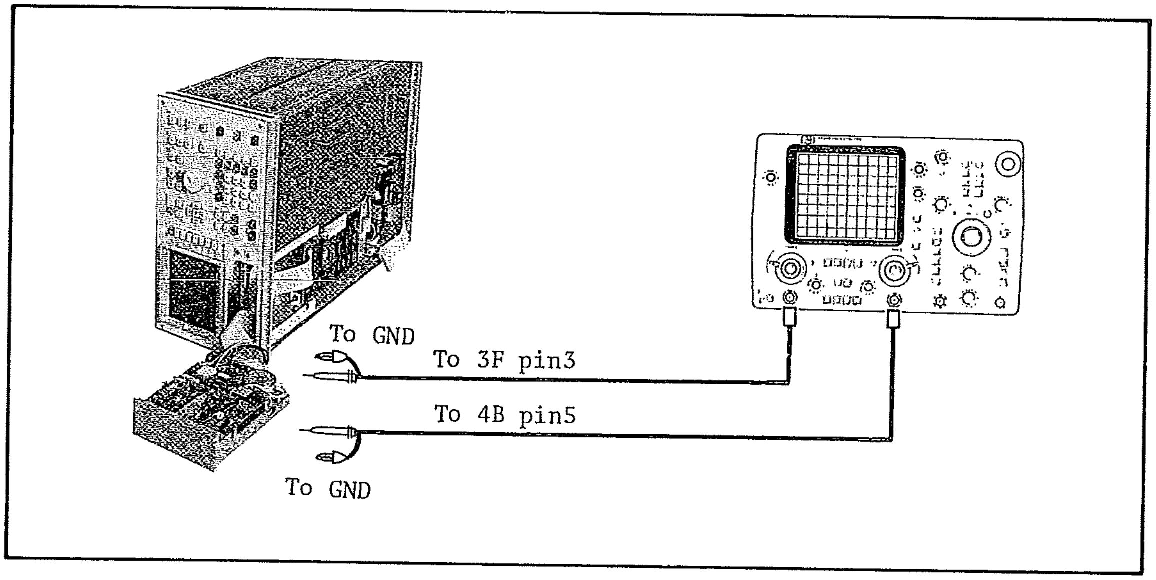


Figure 5-32. Track Zero Switch Check and Adjustment Setup.

EQUIPMENT:

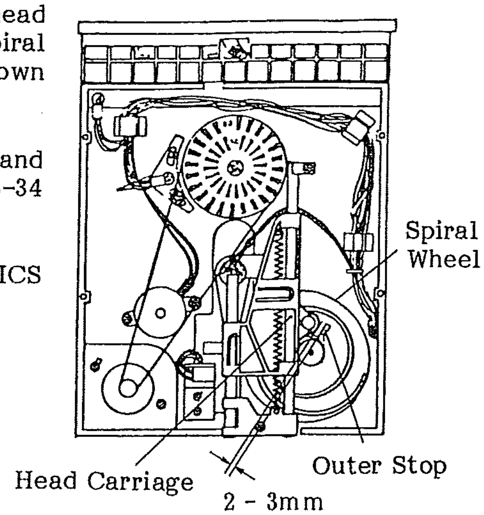
Oscilloscope	HP MODEL 1740A
10 : 1 Divider Probe (2ea)	HP MODEL 10040A
FDD Service Kit	HP P/N 04145-65100

PROCEDURE:

1. Manually set the space between the head carriage and outer stop on the spiral wheel to between 2mm and 3mm, as shown in the figure.

2. Connect channel A input to 3F pin 3, and channel B input to 4B pin 5 (see Figure 5-34 for the locations).

3. Set the 4145A to MSU DIAGNOSTICS Mode, but do not turn on the 4145A.



4. Set the 1740A's controls as follows :

VOLT/DIV	channel A 0.2 channel B 0.2
COUPLING	channel A DC channel B DC (inverted)
DISPLAY	A+B
TIME/DIV	20msec
TRIGGER	INT channel B
POS/NEG.	NEG.
SWEEP VERNIER	ON (if necessary)

5. Insert a blank disc (included in the FDD Service Kit) into the FDD.

6. Turn on the 4145A and the 1740A, then press the EXER- CISER softkey to set the 4145A to MSU EXERCISER.

7. Press the ALT 0-6 softkey to set the FDD to EXERCISER Alternate Movement. The Read/Write head then moves between track 00 and track 06 alternately.

8. Observe and verify that the track zero switch operates between track 02 and track 03 when the Read/Write head moves towards track 39, and between track 03 and track 01 when the Read/Write head moves towards track 00 (see Figure 5-33). If the track zero switch is working properly, step 8 is not necessary.

9. Loosen the retaining screws of the track zero switch (see Figure 5-34 for the location), and adjust the track zero switch manually until it switches between track 02 and track 03 when the Read/Write Head moves towards track 39, and between track 03 and 01 when the Read/Write head moves towards track 00.

10. Tighten the track zero switch retaining screws and apply a small amount of glue.

11. Verify that the head carriage touches the outer stop when the Read/Write Head is moved two tracks from track 00 using the STEP OUT soft key.

CHECKS AND ADJUSTMENTS

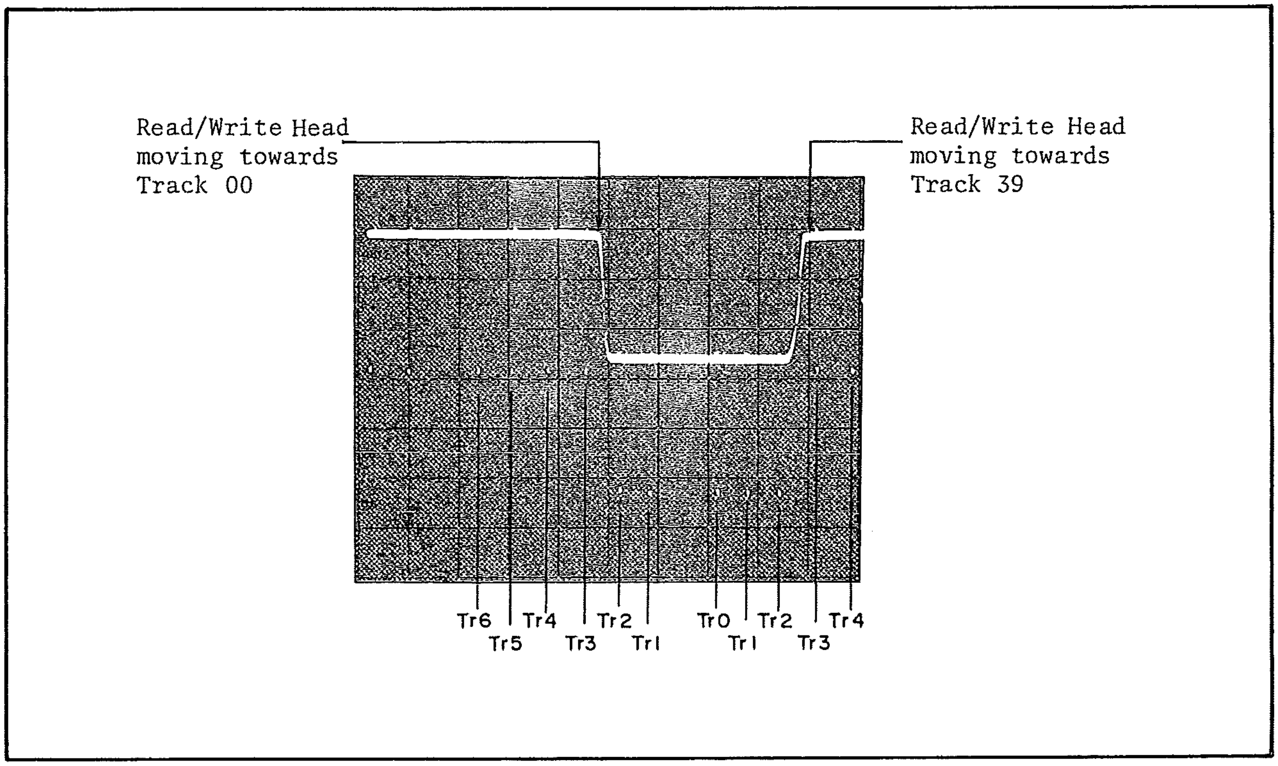


Figure 5-33. Scope Display of Track Zero Switch Switching.

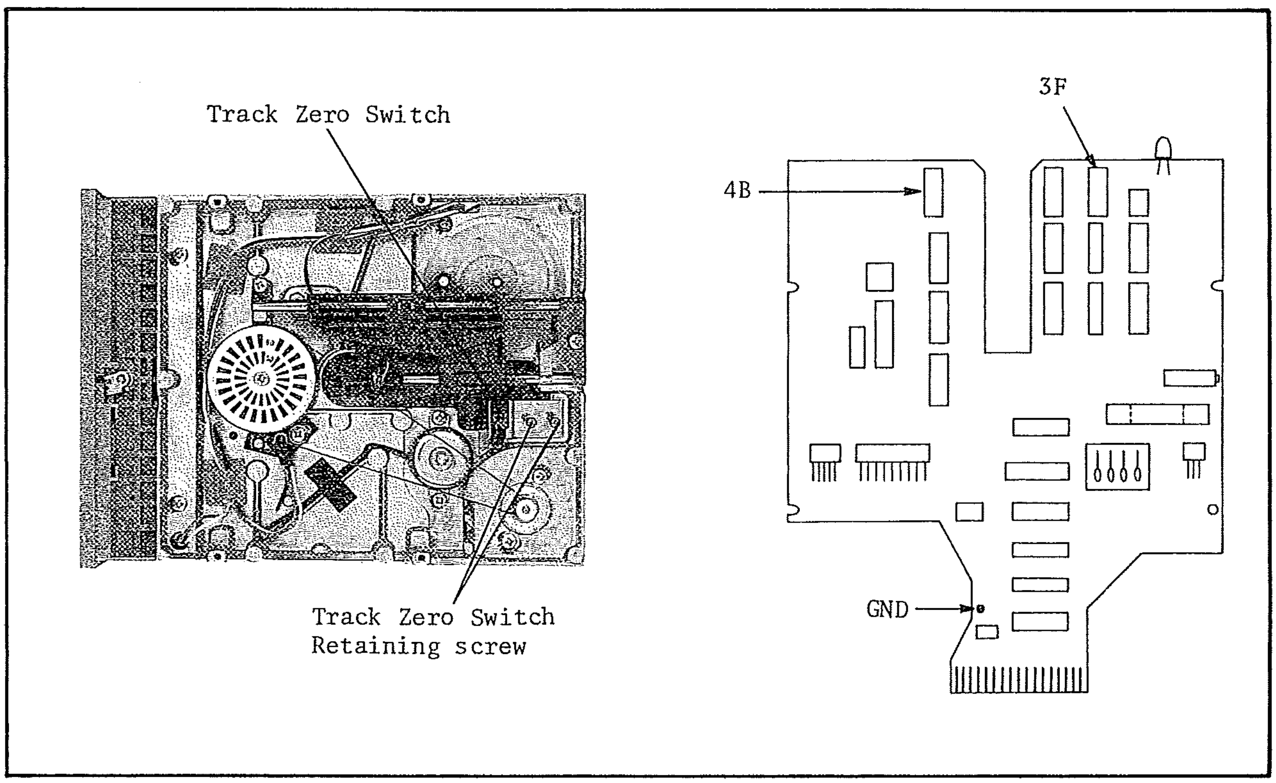


Figure 5-34. Check/Adjustment Point Locations.

5-56. JITTER CHECK AND ADJUSTMENT

PURPOSE: This check and adjustment observes jitter in the read data signal and minimize jitter for proper read data sampling.

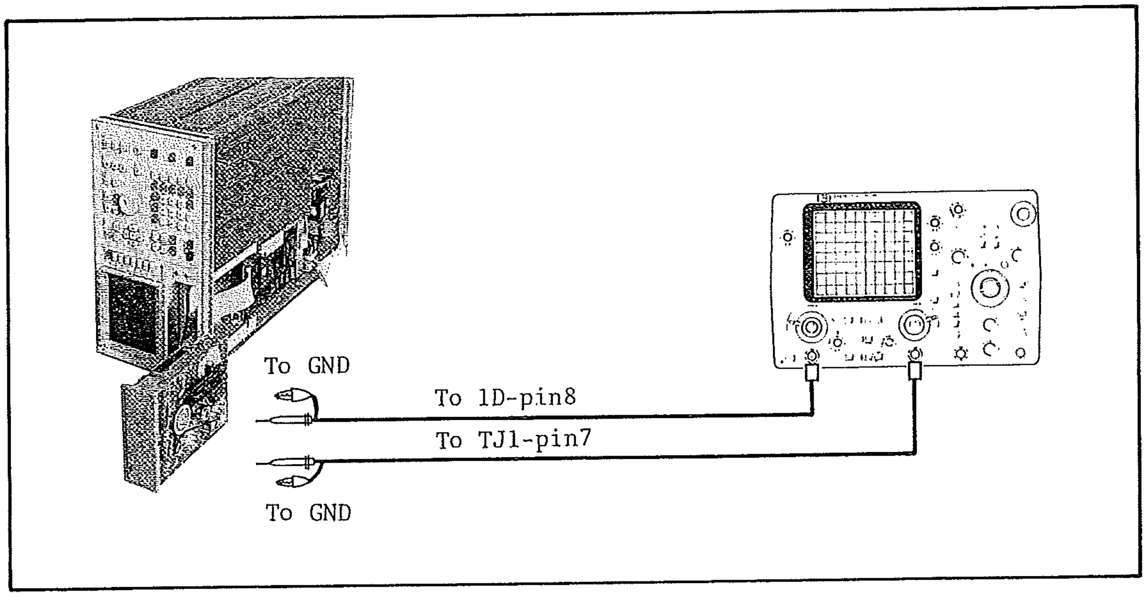


Figure 5-35. Jitter Check and Adjustment Setup.

EQUIPMENT:

Oscilloscope	HP MODEL 1740A
10 : 1 Divider Probe (2ea)	HP MODEL 10040A
FDD Service Kit	HP P/N 04145-65100

PROCEDURE:

1. Connect channel A input to 1D pin 8 and channel B input to TJ1 pin 7 (see Figure 5-37 for locations).

2. Set the 4145A to MSU DIAGNOSTICS Mode, but do not turn on the 4145A.

3. Set the 1740A's controls as follows:

VOLT/DIV	channel A 0.2 channel B 0.02
COUPLING	channel A DC channel B AC
DISPLAY	CHOP
TIME/DIV	0.5 μsec
TRIGGER	INT channel A
POS/NEG.	NEG.
SWEEP MODE	NORM

4. Insert a blank disc (included in the FDD Service Kit) into the FDD.

5. Turn on the 4145A and the 1740A, then press the EXER- CISER softkey to set the 4145A to MSU EXERCISER.

6. Step the Read/Write head of the FDD to track 39 by pressing the STEP IN softkey .

7. Write all "ones" once on all of track 39 by pressing the WRITE 2f softkey.

8. Adjust the trigger level of the 1740A so that the signal from TJ1 pin 7 appears as a "cat's-eye" as shown in Figure 5-36.

9. If jitter is less than 300nsec, steps 10 through 12 are unnecessary.

10. Adjust R69 (see Figure 5-37 for the location) until jitter is less than 300 ns.

11. Step the Read/Write head to track 00 by pressing the TRACK 00 softkey, then write all "ones" on all of track 00 by pressing the WRITE 2f softkey.

12. Verify that the jitter is less than 300 ns. If it exceeds 500 ns, replace the PC Board with new one.

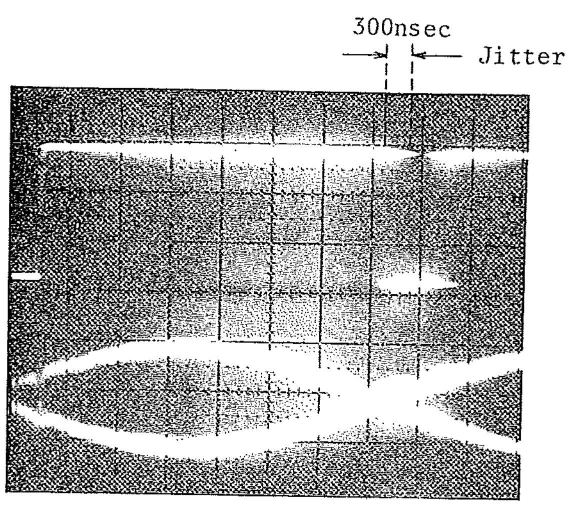


Figure 5-36. Scope Display of Jitter.

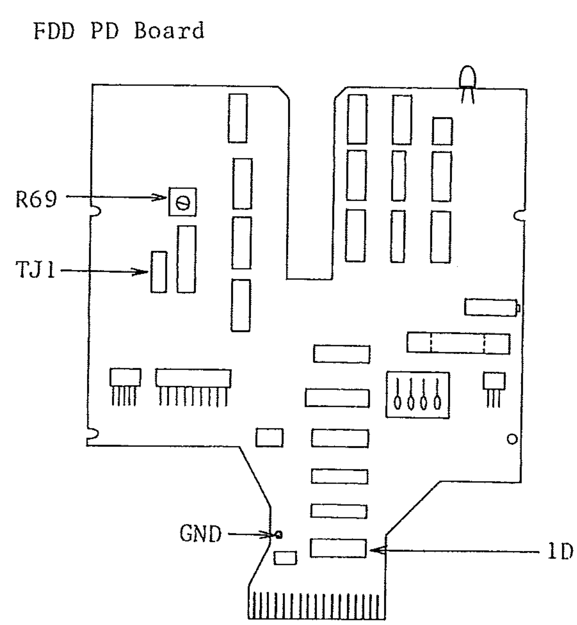


Figure 5-37. Check/Adjustment Point Locations.

5-57. INDEX DETECTOR ALIGNMENT CHECK AND ADJUSTMENT

PURPOSE: This check and adjustment checks and correctly sets the index detector alignment for a correct sector selection.

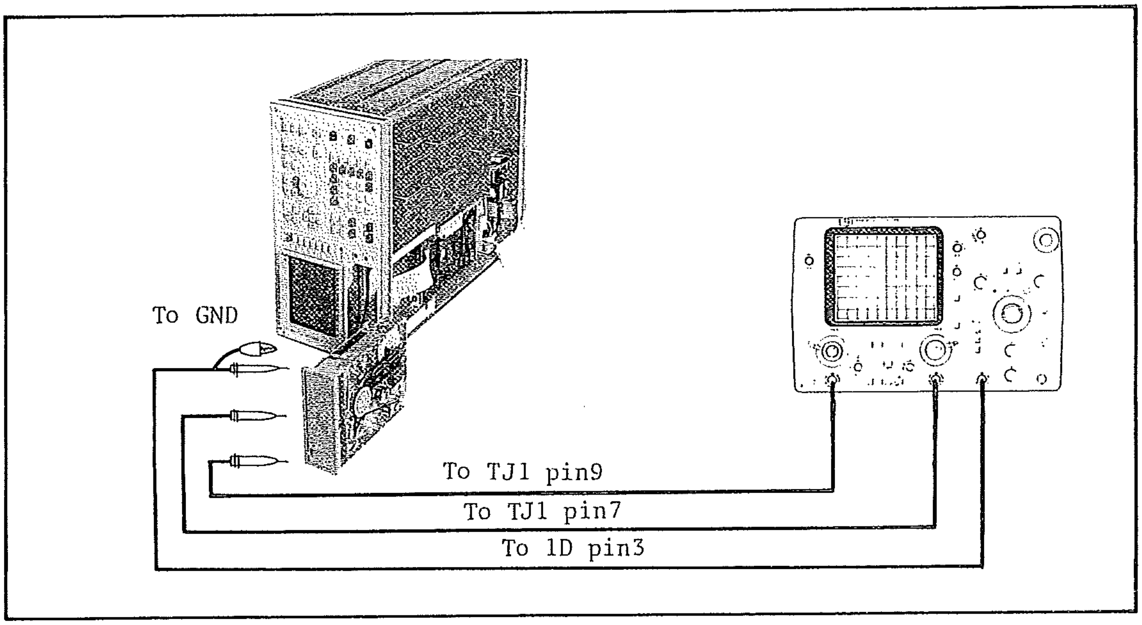


Figure 5-38. Index Detector Alignment Check and Adjustment Setup.

EQUIPMENT:

Oscilloscope	HP MODEL 1740A
10 : 1 Divider Probe (2ea)	HP MODEL 10040A
1 : 1 Probe	HP MODEL 10007B
FDD Service Kit	HP P/N 04145-65100

PROCEDURE:

1. Connect oscilloscope channel A input to TJ1 pin 9 and channel B input to TJ1 pin 7 (see Figure 5-40 for locations) on the flexible-disc Drive (FDD) PC Board using 10 : 1 Divider Probes. Also, connect EXT TRIGGER input to 1D pin 3 (see Figure 5-41 for location) for the external trigger.

2. Set the 4145A to MSU DIAGNOSTICS Mode, but do not turn on the 4145A.

3. Set the 1740A's controls as follows :

VOLT/DIV	channel A 0.05 channel B 0.05	
COUPLING	channel A AC channel B AC	 (Inverted)
DISPLAY	A+B	
TIME/DIV	100 μsec	
TRIGGER	EXT	
POS/NEG.	NEG.	
SWEEP MODE	NORM	

4. Insert the CE disc (included in the FDD Service Kit) into the FDD, and turn on the 4145A and the 1740A.

5. Press the EXER- CISER softkey to set the 4145A to MSU EXERCISER.

6. Check whether the index alignment gap is within the 450± 200 μs limit. Refer to Figure 5-39 for a pictorial explanation of the gap. If the gap is out of the limit, perform steps 7 through 9.

7. Loosen the retaining screw of the index detector (photo transistor) holder (see Figure 5-40 for the location).

8. Adjust the holder position using the eccentric rod (included in FDD Service Kit) until the time delay from the trigger point to the start point of a data burst is within 450 ±20 μs (see Figure 5-39).

9. Tighten the retaining screw and apply a small amount of glue.

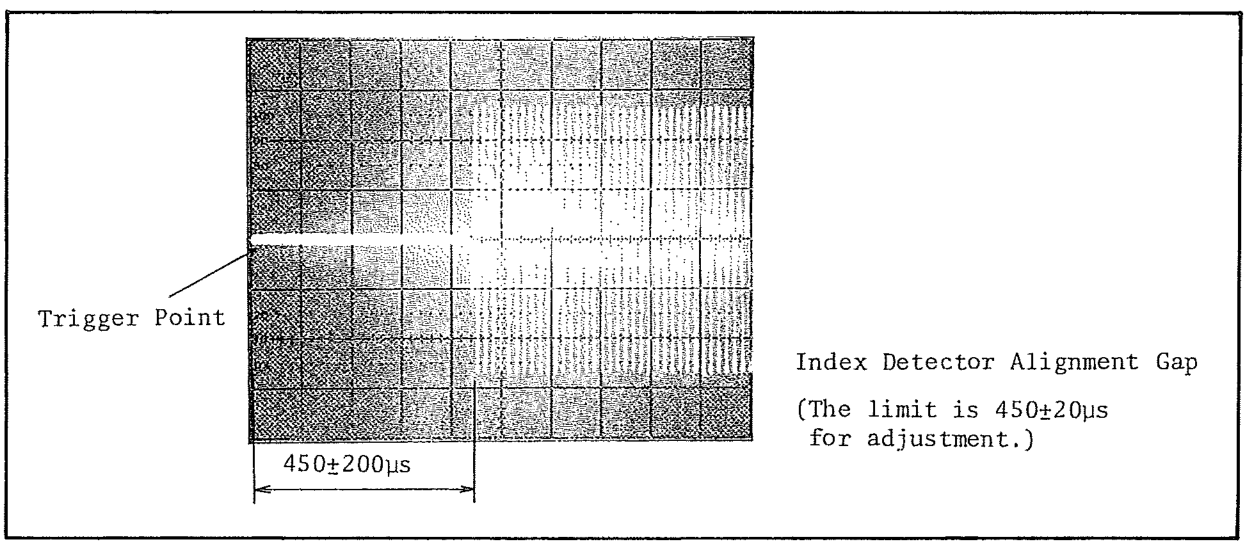


Figure 5-39. Index Detector Alignment Gap.

CHECKS AND ADJUSTMENTS

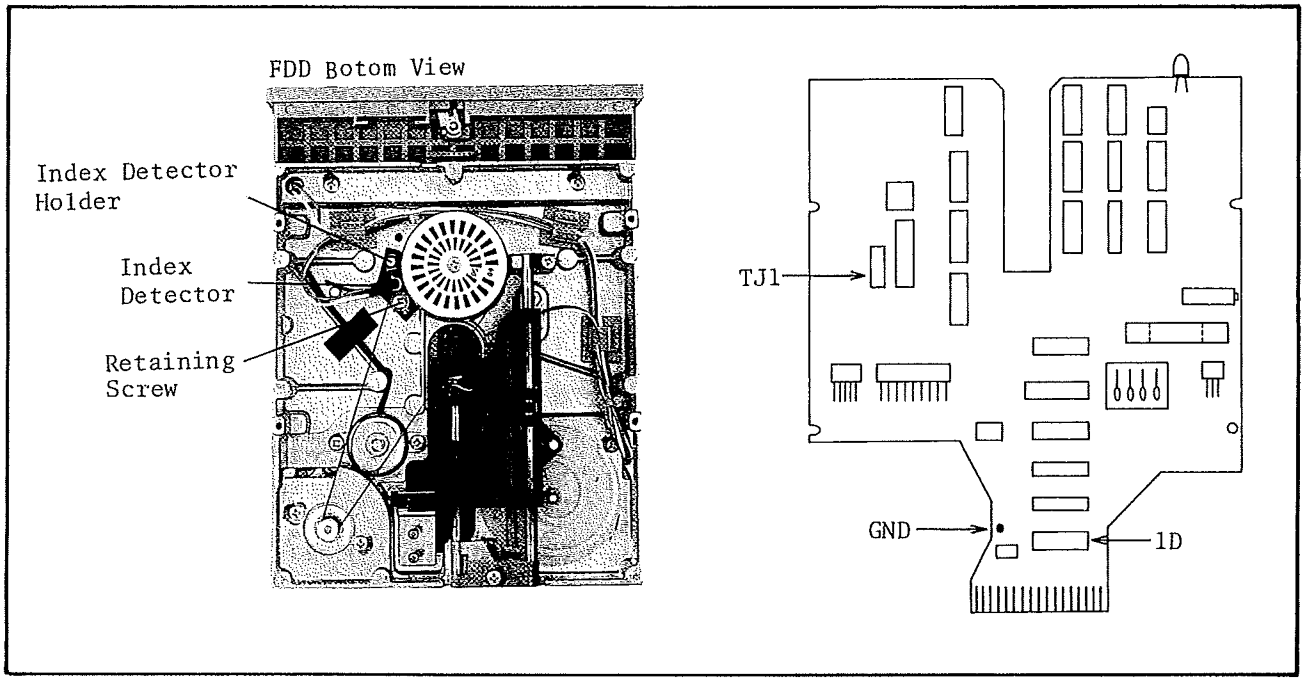


Figure 5-40. Check/Adjustment Point Locations.

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION

6-2. This section contains information for ordering parts. Table 6-1 lists abbreviations used in the parts list and throughout the manual. Table 6-3 lists all replaceable parts in reference designator order. Table 6-2 contains the names and addresses that correspond to the manufacturer's code numbers.

6-3. ABBREVIATIONS

6-4. Table 6-1 lists abbreviations used in parts list, schematics and throughout the manual. In some cases, two forms of abbreviations are used, one in all capital letters, and one in partial capitals or no capitals. This occurs because the abbreviations in parts list are always all capitals. However, in the schematic and in other parts of the manual, other abbreviation forms with both lower case and upper case letters are used.

6-5. REPLACEABLE PARTS LIST

6-6. Table 6-3 is a list of replaceable parts and is organized as follows :

a. Electrial assemblies and their components in alphanumerical order by reference designation.
b. Chassis-mounted parts in alphanumerical order by reference disignation.
c. Miscellaneous parts.
d. Illustrated parts breakdowns, if appropriate.

The information for each part includes :

a. The Hewlett-Packard part number.
b. The total quantity (Qty) in the instrument.
c. A description of the part.
d. A typical manufacturer of the part in a five-digit code.
e. The manufacturer's number for the part.

Table 6-1. List of Reference Designators and Abbreviations

REFERENCE DESIGNATORS

A	= assembly	E	= misc electronic part	P	= plug	U	= integrated circuit
B	= motor	F	= fuse	Q	= transistor	V	= vacuum, tube, neon bulb, photocell, etc.
BT	= battery	FL	= filter	R	= resistor	VR	= voltage regulator
C	= capacitor	J	= jack	RT	= thermistor	W	= cable
CP	= coupler	K	= relay	S	= switch	X	= socket
CR	= diode	L	= inductor	T	= transformer	Y	= crystal
DL	= delay line	M	= meter	TB	= terminal board		
DS	= device signaling (lamp)	MP	= mechanical part	TP	= test point		

ABBREVIATIONS

A	= amperes	H	= henries	NPN	= negative-positive-negative	RWV	= reverse working voltage
A.F.C.	= automatic frequency control	HEX	= hexagonal	NRFR	= not recommended for field replacement	S-B	= slow-blow
AMPL	= amplifier	HG	= mercury	NSR	= not separately replaceable	SCR	= screw
B.F.O.	= beat frequency oscillator	HR	= hour(s)	OBD	= order by description	SE	= selenium
BE CU	= beryllium copper	Hz	= hertz	OH	= oval head	SECT	= section(s)
BH	= binder head	IF	= intermediate freq.	OX	= oxide	SEMICON	= semiconductor
BP	= bandpass	IMPG	= impregnated	P	= peak	SI	= silicon
BRS	= brass	INCD	= incandescent	PC	= printed circuit	SIL	= silver
BWO	= backward wave oscillator	INCL	= include(s)	p	= pico = 10^{-12}	SL	= slide
CCW	= counter-clockwise	INS	= insulation(ed)	PH BRZ	= phosphor bronze	SPG	= spring
CER	= ceramic	INT	= internal	PHL	= Phillips	SPL	= special
CMO	= cabinet mount only	k	= kilo = 1000	PIV	= peak inverse voltage	SST	= stainless steel
COEF	= coefficient	LH	= left hand	PNP	= positive-negative-positive	SR	= split ring
COM	= common	LIN	= linear taper	P/O	= part of	STL	= steel
COMP	= composition	LK WASH	= lock washer	POLY	= polystyrene	TA	= tantalum
COMPL	= complete	LOG	= logarithmic taper	PORC	= porcelain	TD	= time delay
CONN	= connector	LPF	= low pass filter	POS	= position(s)	TGL	= toggle
CP	= cadmium plate	m	= milli = 10^{-3}	POT	= potentiometer	THD	= thread
CRT	= cathode-ray tube	M	= meg = 10^{6}	PP	= peak-to-peak	TI	= titanium
CW	= clockwise	MET FLM	= metal film	PT	= point	TOL	= tolerance
DEPC	= deposited carbon	MET OX	= metallic oxide	PWV	= peak working voltage	TRIM	= trimmer
DR	= drive	MFR	= manufacturer	RECT	= rectifier	TWT	= traveling wave tube
ELECT	= electrolytic	MINAT	= miniature	RF	= radio frequency	μ	= micro = 10^{-6}
ENCAP	= encapsulated	MOM	= momentary	RH	= round head or right hand	VAR	= variable
EXT	= external	MTG	= mounting	RMO	= rack mount only	VDCW	= dc working volts
F	= farads	MY	= "mylar"	RMS	= root-mean square	W/	= with
f	= femto = 10^{-15}	n	= nano = 10^{-9}			W	= watts
FH	= flat head	N/C	= normally closed			WIV	= working inverse voltage
FIL H	= fillister head	NE	= neon			WW	= wirewound
FXD	= fixed	NI PL	= nickel plate			W/O	= without
G	= giga = 10^{9}	N/O	= normally open				
GE	= germanium	NPO	= negative positive zero (zero temperature coefficient)				
GL	= glass						
GRD	= ground(ed)						

The total quantity for each part is given only once — at the first appearance of the part number in the list.

Part numbers for the shield cases, screws, cable clamps, and cables (except for wiring on a board) on each board assembly, are not listed in Table 6-3. If required these parts must be ordered separately when ordering a complete board assembly. They are listed in Table 6-4 and 6-5 as Board Mounted Hardware and Cable Assemblies respectively.

6-7. ORDERING INFORMATION

6-8. To order a part listed in the replaceable parts table, give the Hewlett-Packard part number, indicate the quantity required, and address the order to the nearest Hewlett-Packard office.

6-9. To order a part that is not listed in the replaceable parts table, state the full instrument model and serial number, and description and function of the part, and the number of parts required. Address your order to the nearest Hewlett-Packard office.

6-10. DIRECT MAIL ORDER SYSTEM

6-11. Within the USA, Hewlett-Packard can supply parts through a direct mail order system. Advantages of using the system are :

a. Direct ordering and shipment from the HP Parts Center in Mountain View, California.

b. No maximum or minimum on any mail order (there is a minimum order amount for parts ordered through a local HP Office when the orders require billing and invoicing).

c. Prepaid transportation (there is a small handling charge for each order).

d. No invoices — to provide these advantages, a check or money order must accompany each order.

6-14. Mail order forms and specific ordering information are available through your local HP Office. Addresses and phone numbers are located at the back of this manual.

Table 6-2. Manufacturers Code Lists

MFR NO.	MANUFACTURER NAME	ADDRESS		ZIP CODE
S0167	FUJITSU LTD	TOKYO	JP	
S0545	NIPPON ELECTRIC CO	TOKYO	JP	
00000	ANY SATISFACTORY SUPPLIER			
01121	ALLEN-BRADLEY CO	MILWAUKEE	WI	53204
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS	TX	75222
02114	FERROXCUBE CORP	SAUGERTIES	NY	12477
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX	AZ	85008
06383	PANDUIT CORP	TINLEY PARK	IL	60477
06665	PRECISION MONOLITHICS INC	SANTA CLARA	CA	95050
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW	CA	94042
12969	UNITRODE CORP	WATERTOWN	MA	02172
14099	SEMTECH CORP	NEWBURY PARK	CA	91320
14936	GENERAL INSTR CORP SEMICON PROD GP	HICKSVILLE	NY	11802
17856	SILICONIX INC	SANTA CLARA	CA	95054
19701	MEPCO/ELECTRA CORP	MINERAL WELLS	TX	76067
24355	ANALOG DEVICES INC	NORWOOD	MA	02062
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD	PA	16701
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA	CA	95051
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO	CA	94304
3L585	RCA CORP SOLID STATE DIV	SOMERVILLE	NJ	
34649	INTEL CORP	MOUNTAIN VIEW	CA	95051
52763	STETTNER-TRUSH INC	CAZENOVIA	NY	13035
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS	MA	01247
72136	ELECTRO MOTIVE CORP	FLORENCE	SC	06226
75042	TRW INC PHILADELPHIA DIV	PHILADELPHIA	PA	19108
75915	LITTELFUSE INC	DES PLAINES	IL	60016
8E175	BURR BROWN CO	TUCSON	AZ	35801
91637	DALE ELECTRONICS INC	COLUMBUS	NE	68601
98291	SEALECTRO CORP	MAMARONECK	NY	10544

Table 6-3. Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1	04145-66501	2	1	GRAPHICS DISPLAY CONTROL BOARD ASS'Y	28480	04145-66501
A1C1	0180-2205	3	1	CAPACITOR-FXD .33UF+-10% 35VDC TA	56289	150D334X9035A2
A1C2	0160-4832	4	17	CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A1C3	0160-4835	7	181	CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C4	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C5	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C6	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C7	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C8	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C9	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C10	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C11	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C12	0140-0196	3	5	CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A1C13	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C14	0160-2150	5	1	CAPACITOR-FXD 33PF +-5% 300VDC MICA	28480	0160-2150
A1C15	0140-0196	3		CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A1C16	0160-2307	4	1	CAPACITOR-FXD 47PF +-5% 300VDC MICA	28480	0160-2307
A1C17	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C18	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C19	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C20	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C21	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C22	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C23	0180-0228	6	4	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A1C25	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A1C26	0180-0197	8	8	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1DS1	1990-0486	6	10	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A1J1	1251-4822	6	20	CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A1J2	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A1J3	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A1J4	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A1J5	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A1L1	9100-3139	5	9	INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A1L2	9100-1788	6	4	CHOKE-WIDE BAND ZMAX=680 OHM@ 180 MHZ	02114	VK200 20/4B
A1Q1	1853-0010	2	1	TRANSISTOR PNP SI TO-18 PD=360MW	28480	1853-0010
A1R1	0683-1035	1	51	RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R2	0698-3451	0	1	RESISTOR 133K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1333-F
A1R3	0757-0199	3	1	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A1R4	0683-5615	1	1	RESISTOR 560 5% .25W FC TC=-400/+600	01121	CB5615
A1R5	0698-3455	4	1	RESISTOR 261K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2613-F
A1R6	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R7	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R8	0683-3315	4	9	RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A1R9	0683-2215	1	1	RESISTOR 220 5% .25W FC TC=-400/+600	01121	CB2215
A1R10	0683-1025	3	4	RESISTOR 1K 5% .25W FC TC=-400/+700	01121	CB2225
A1R11	0757-0410	1	1	RESISTOR 301 1% .125W F TC=0+-100	24546	C4-1/8-T0-301R-F
A1R12	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1R13	0683-4735	4	13	RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A1R14	0683-1025	9	47	RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A1R15	0683-2235	5	5	RESISTOR 22K 5% .25W FC TC=-400/+800	01121	CB2235
A1R16	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A1U1	1826-0180	0	1	IC TIMER TTL MONO/ASTBL	01295	NE555P
A1U2	1820-1423	4	1	IC MV TTL LS MONOSTBL RETRIG DUAL	01295	SN74LS123N
A1U3	1820-1197	9	7	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A1U4	1820-0511	9	1	IC GATE TTL AND QUAD 2-INP	01295	SN7408N
A1U5	1820-1194	6	8	IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS193N
A1U6	1820-1194	6		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS193N
A1U7	1820-1194	6		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS193N
A1U8	04145-85028	4		IC NMOS 32768 (32) EPROM 450-NS 3-S	34649	D2732
	1200-0541	1	16	SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A1U9	1820-1430	3	4	IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS161AN
A1U10	1820-1112	8	13	IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A1U11	1820-1208	3	5	IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N
A1U12	1820-1416	5	2	IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N
A1U13	1820-1470	1	4	IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N
A1U14	1820-1470	1		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N
A1U15	1820-1470	1		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N
A1U16	1820-1196	8	4	IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N
A1U17	1820-1997	7	6	IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A1U18	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A1U19	1820-2024	3	12	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A1U20	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A1U21	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A1U22	1820-1433	6	1	IC SHF-RGTR TTL LS R-S SERIAL-IN PRL-OUT	01295	SN74LS164N
A1U23	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A1U24	1820-1411	0	1	IC LCH TTL LS D-TYPE 4-BIT	01295	SN74LS75N
A1U25	1820-1194	6		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS193N
A1U26	1820-1194	6		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS193N
A1U27	1820-1194	6		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS193N
A1U28	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N
A1U29	1818-1877	7	4	IC-DIGITAL S-RAM	S0167	MB8128-15
	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A1U30	1818-1877	7		IC-DIGITAL S-RAM	S0167	MB8128-15
	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A1U31	1818-1877	7		IC-DIGITAL S-RAM	S0167	MB8128-15
	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A1U32	1818-1877	7		IC-DIGITAL S-RAM	S0167	MB8128-15
	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A1U33	1820-0495	8	2	IC DCDR TTL 4-TO-16-LINE 4-INP	01295	SN74154N
A1U34	1820-0174	0	1	IC INV TTL HEX	01295	SN7404N
A1U35	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A1U36	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A1U37	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A1U38	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A1U39	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A1U40	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A1U41	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A1U42	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A1U43	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A1U44	1820-1997	7		IC FF TTL LS D-TYPE POS-EDGE-TRIG PRL-IN	01295	SN74LS374N
A1W1	1258-0141	8	24	JUMPER-REM	28480	1258-0141
A1W2	1258-0141	8		JUMPER-REM	28480	1258-0141
A1W3	1258-0141	8		JUMPER-REM	28480	1258-0141
A1W4	1258-0141	8		JUMPER-REM	28480	1258-0141
A1W5	1258-0141	8		JUMPER-REM	28480	1258-0141
A1Y1	0410-1337	9	1	CRYSTAL- 20 MHZ	28480	0410-1337
	8195-0005	0	1	RESISTOR-ZERO OHMS 22 AWG LEAD DIA		
A2	04145-66502	3	1	MICROPROCESSOR DIGITAL CONTROL BOARD ASS'Y	28480	04145-66502
A2C1	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C2	0160-2200	6	1	CAPACITOR-FXD 43PF +-5% 300VDC MICA	28480	0160-2200
A2C3	0160-2203	9	1	CAPACITOR-FXD 91PF +-5% 300VDC MICA 0+70	28480	0160-2203
A2C4	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C5	0180-1083	3	13	CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A2C6	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C7	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C8	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C9	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C10	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C11	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C12	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C13	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C14	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C15	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C16	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C17	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C18	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C19	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C20	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C21	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C22	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C23	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C24	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C25	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C26	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C27	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C28	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C29	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C30	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C31	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C32	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C33	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C34	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C35	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C36	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C37	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C38	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C39	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A2C40	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A2C41	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C42	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C43	0140-0196	3		CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A2C44	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C45	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C46	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A2C47	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C48	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C49	0160-2204	0	12	CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A2C50	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C51	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C52	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C53	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C54	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C55	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A2C56	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C57	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C58	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C59	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2C60	0180-0197			CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C61	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C62	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A2CR1	1901-0040	1	26	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A2DS1	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A2DS2	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A2DS3	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A2J1	1200-0654	7	4	SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A2J2	1200-0607	0	4	SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A2J3	1200-0607	0		SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A2J4	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A2J5	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A2J6	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A2J7	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A2J8	1251-4484	6	2	CONNECTOR 4-PIN M POST TYPE	28480	1251-4484
A2J9	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A2L1	9100-1788	6		CHOKE-WIDE BAND ZMAX=680 OHM@ 180 MHZ	02114	VK200 20/4B
A2L2	9100-3139	5		INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A2L3	9100-1788	6		CHOKE-WIDE BAND ZMAX=680 OHM@ 180 MHZ	02114	VK200 20/4B
A2L4	9100-1629	4	1	INDUCTOR RF-CH-MLD 47UH 5% .166DX.385LG	28480	9100-1629
A2R1	1810-0269	3	8	NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0269
A2R2	0683-1045	3	9	RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A2R3	0683-2205	9	5	RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB2205
A2R4	0683-2205	9		RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB2205
A2R5	0683-2205	9		RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB2205
A2R6	0683-2205	9		RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB2205
A2R7	0683-4715	0	4	RESISTOR 470 5% .25W FC TC=-400/+600	01121	CB4715
A2R8	0683-4715	0		RESISTOR 470 5% .25W FC TC=-400/+600	01121	CB4715
A2R9	0683-4715	0		RESISTOR 470 5% .25W FC TC=-400/+600	01121	CB4715
A2R10	0698-3438	3	1	RESISTOR 147 1% .125W F TC=0+-100	24546	C4-1/8-T0-147R-F
A2R11	1810-0269	3		NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0269
A2R12	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A2R13	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A2R14	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A2R15	0757-0417	8	1	RESISTOR 562 1% .125W F TC=0+-100	24546	C4-1/8-T0-562R-F
A2R16	1810-0305	8		NETWORK-RES 9-SIP4.7K OHM X 8	28480	1810-0305
A2R17	1810-0305	8	1	NETWORK-RES 9-SIP4.7K OHM X 8	28480	1810-0305
A2SW1	3101-1973	7	3	SWITCH-SL 7-1A DIP-SLIDE-ASSY .1A 50VDC	28480	3101-1973
A2U1	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N
A2U2	1820-1199	1	6	IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A2U3	1820-2358	6	1	IC-68B00	28480	1820-2358
A2U4	1820-2075	4	2	IC MISC TTL LS	01295	SN74LS245N
A2U5	1818-1396	5	16	IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U6	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U7	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U8	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U9	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U10	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U11	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U12	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U13	04145-85023	4	8	IC NMOS 32768 (32K) EPROM 450-NS 3-S	34649	D2732
A2U14	04145-85034	4		IC NMOS 32768 (32K) EPROM 450-NS 3-S	34649	D2732
A2U15	1820-2746	6	1	IC-DIGITAL MB8867	28480	1820-2746

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A2U16	1820-2741	1	1	IC-DIGITAL MC3480	28480	1820-2741
A2U17	1820-2742	2	1	IC MISC TTL S	04713	MC3242AP
A2U18	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U19	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U20	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U21	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U22	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U23	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U24	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U25	1818-1396	5		IC-DIGITAL MB8116E	S0545	UP416C-2(SELECTED)
A2U26	04145-85021	4		IC NMOS 32768 (32K) EPROM 450-NS 3-S	34649	D2732
A2U27	04145-85022	4		IC NMOS 32768 (32K) EPROM 450-NS 3-S	34649	D2732
A2U28	1820-1425	6	2	IC SCHMITT-TRIG TTL LS NAND QUAD 2-INP	01295	SN74LS132N
A2U29	1820-0054	5	1	IC GATE TTL NAND QUAD 2-INP	01295	SN7400N
A2U30	1820-1491	6	4	IC BFR TTL LS NON-INV HEX 1-INP	01295	SN74LS367AN
A2U31	1820-1794	2	11	IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A2U32	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A2U33	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A2U34	1820-1202	7	3	IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N
A2U35	1820-1216	3	5	IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A2U36	1820-1281	2	3	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N
A2U37	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A2U38	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A2U39	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A2U40	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A2U41	1820-1201	6	3	IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N
A2U42	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A2U43	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N
A2U44	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N
A2U45	1820-1281	2	2	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N
A2U46	1820-1989	7		IC CNTR TTL LS BIN DUAL 4-BIT	07263	74LS393PC
A2U47	1820-1202	7		IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N
A2U48	1820-1991	1	3	IC CNTR TTL LS DECD DUAL 4-BIT	01295	SN74LS390N
A2U49	1820-1991	1		IC CNTR TTL LS DECD DUAL 4-BIT	01295	SN74LS390N
A2U50	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A2U51	1820-1491	6		IC BFR TTL LS NON-INV HEX 1-INP	01295	SN74LS367AN
A2U52	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A2U53	1820-1491	6		IC BFR TTL LS NON-INV HEX 1-INP	01295	SN74LS367AN
A2U54	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N
A2U55	1820-1196	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG COM	01295	SN74LS174N
A2U56	1820-1491	6		IC BFR TTL LS NON-INV HEX 1-INP	01295	SN74LS367AN
A2U57	1820-1470	1		IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS157N
A2U58	1820-2743	3	1	IC-DIGITAL MC68B50	28480	1820-2743
A2W1	1251-4787	2	2	SHUNT-DIP 8-POSITION	28480	1251-4787
A2W2	1258-0141	8		JUMPER-REM	28480	1258-0141
A2W3	1258-0141	8		JUMPER-REM	28480	1258-0141
A2W4	1258-0141	8		JUMPER-REM	28480	1258-0141
A2W5	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A2W6	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A2Y1	0410-1377	7	1	CRYSTAL 8 MHZ	28480	0410-1377
A3	04145-66503	4	1	SMU CONTROL AND A-D CONVERTER BOARD ASS'Y	28480	04145-66503
A3C1	0160-0301	4	1	CAPACITOR-FXD .012UF +-10% 200VDC POLYE	28480	0160-0301
A3C2	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A3C3	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C4	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C5	0160-0127	2	17	CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A3C6	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A3C7	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A3C8	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A3C9	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A3C10	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A3C11	0160-4822	2	3	CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A3C12	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C13	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C14	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C15	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C16	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C17	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C18	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C19	0160-2306	3		CAPACITOR-FXD 27PF +-5% 300VDC MICA	28480	0160-2306
A3C20	0160-2306	3		CAPACITOR-FXD 27PF +-5% 300VDC MICA	28480	0160-2306
A3C21	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C22	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C23	0180-1746	5	7	CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A3C24	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A3C25	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3C26	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C27	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C28	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C29	0160-5432	2	1	CAPACITOR-FXD 0.01UF	28480	0160-5432
A3C30	0160-4791	4	1	CAPACITOR-FXD 10PF +-5% 100VDC CER 0+-30	28480	0160-4791
A3C31	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C32	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C33	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C34	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C35	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C36	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C37	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A3C38	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A3C39	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A3C40	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A3C41	0160-5493			CAPACITOR-FXD .1UF		
A3C42	0160-5493			CAPACITOR-FXD .1UF		
A3C43	0160-5493			CAPACITOR-FXD .1UF		
A3C44	0160-5493			CAPACITOR-FXD .1UF		
A3C45	0160-5493			CAPACITOR-FXD .1UF		
A3C46	0160-5493			CAPACITOR-FXD .1UF		
A3C47	0160-5493			CAPACITOR-FXD .1UF		
A3C48	0160-5493			CAPACITOR-FXD .1UF		
A3C49	0160-5493			CAPACITOR-FXD .1UF		
A3C50	0160-5493			CAPACITOR-FXD .1UF		
A3C51	0160-5493			CAPACITOR-FXD .1UF		
A3C52	1810-0585	6	3	CAPACITOR-FXD 470PF X 8	28480	1810-0585
A3C53	1810-0585	6		CAPACITOR-FXD 470PF X 8	28480	1810-0585
A3C54	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A3C55	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A3C56	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A3C57	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A3CP1	1990-0494	6	1	OPTO-ISOLATOR LED-PDIO/XSTR IF=20MA-MAX	28480	5082-4370
A3CP2	1990-0444	6	6	OPTO-ISOLATOR LED-PDIO/XSTR IF=25MA-MAX	28480	6N136
A3CP3	1990-0444	6		OPTO-ISOLATOR LED-PDIO/XSTR IF=25MA-MAX	28480	6N136
A3CR1	1902-0064	1	2	DIODE-ZNR 7.5V 5% DO-35 PD=.4W TC=+.05%	28480	1902-0064
A3CR2	1902-0064	1		DIODE-ZNR 7.5V 5% DO-35 PD=.4W TC=+.05%	28480	1902-0064
A3CR3	1901-0518	8	4	DIODE-SM SIG SCHOTTKY	28480	1901-0518
A3CR4	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A3CR5	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A3CR6	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A3DS1	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A3DS2	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A3DS3	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A3DS4	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A3J1	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A3J2	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A3J3	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A3J4	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A3J5	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A3J6	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A3J7	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A3J8	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A3J9	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A3J10	1200-0654	7		SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A3J11	1200-0607	0		SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A3J12	1200-0607	0		SOCKET-IC 16-CONT DIP DIP-SLDR	28480	1200-0607
A3J13	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A3J14	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A3J15	1251-4484	6		CONNECTOR 4-PIN M POST TYPE	28480	1251-4484
A3J16	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A3L1	9140-0114	4	12	INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A3L2	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A3L3	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A3L4	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A3L5	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A3L6	9100-3139	5		INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A3Q1	1853-0281	9	4	TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A3Q2	1854-0477	7	4	TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A3Q3	1853-0459	3	19	TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A3Q4	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A3Q5	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3R1	2100-3354	9	2	RESISTOR-TRMR 50K 10% C SIDE-ADJ 1-TRN	28480	2100-3354
A3R2	0698-3156	2	1	RESISTOR 14.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1472-F
A3R3	0698-3159	5	1	RESISTOR 26.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2612-F
A3R4	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R5	0683-5645	7	4	RESISTOR 560K 5% .25W FC TC=-800/+900	01121	CB5645
A3R6	0699-0752	0	2	RESISTOR 1.78K .1% .125W F TC=0+-25	28480	0699-0752
A3R7	0757-0278	9	3	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A3R8	0683-1015	7	7	RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A3R9	0683-2725	8	6	RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A3R10	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R11	0698-0083	8	1	RESISTOR 1.96K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1961-F
A3R12	0683-1005	5	7	RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A3R13	0683-5645	7		RESISTOR 560K 5% .25W FC TC=-800/+900	01121	CB5645
A3R14	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R15	0683-6815	5	8	RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A3R16	0683-6815	5		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A3R17	0683-6815	5		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A3R18	0683-6815	5		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A3R19	0757-0317	7	1	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1331-F
A3R20	0699-0597	1	2	RESISTOR 2.26K .1% .125W F TC=0+-25	28480	0699-0597
A3R21	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R22	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R23	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R24	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R25	0699-0918	0	2	RESISTOR-22.65K OHM 0.1%	28480	0699-0918
A3R26	0699-0919	1	1	RESISTOR-4.096K OHM 0.1%	28480	0699-0919
A3R27	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R28	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R29	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R30	2100-3210	6	2	RESISTOR-TRMR 10K 10% C TOP-ADJ 1-TRN	28480	2100-3210
A3R31	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R32	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R33	0683-1005	5		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A3R34	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R35	0683-3315	4		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A3R36	0683-3315	4		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A3R37	0683-3315	4		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A3R38	0683-3335	8	23	RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A3R39	0683-2205	9		RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB2205
A3R40	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R41	0683-1045	3		RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A3R42	0683-1015	7		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A3R43	0683-3925	2	3	RESISTOR 3.9K 5% .25W FC TC=-400/+700	01121	CB3925
A3R44	0683-1815	5	2	RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A3R45	0683-3945	6	4	RESISTOR 390K 5% .25W FC TC=-800/+900	01121	CB3945
A3R46	0683-5625	3	2	RESISTOR 5.6K 5% .25W FC TC=-400/+700	01121	CB5625
A3R47	1810-0269	3		NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0269
A3R48	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R49	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R50	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R51	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R52	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R53	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R54	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R55	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R56	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R57	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R58	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R59	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R60	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A3R61	0683-3315	4		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A3R62	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R63	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3R64	0683-1525	4	3	RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A3R65	0683-3945	6		RESISTOR 390K 5% .25W FC TC=-800/+900	01121	CB3945
A3R66	0683-5625	3		RESISTOR 5.6K 5% .25W FC TC=-400/+700	01121	CB5625
A3R67	0683-1815	5		RESISTOR 180 5% .25W FC TC=-400/+600	01121	CB1815
A3R68	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A3S1	3101-1973	7		SWITCH-SL 7-1A DIP-SLIDE-ASSY .1A 50VDC	28480	3101-1973
A3T1	9100-4212	7	1	TRANSFORMER-PULSE 132F1	28480	9100-4212
A3U1	1826-0013	8	3	IC OP AMP LOW-NOISE TO-99 PKG	06665	SSS741CJ
A3U2	1813-0251	9	2	IC-DAC71-CSB-I	28480	1813-0251
A3U3	1820-2738	6	2	IC-DEG AM2503PC	27014	DM2503CN
A3U4	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A3U5	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A3U6	1820-1858	9	5	IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U7	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A3U8						
A3U9	04145-85015	4		IC NMOS 32768 (32K) EPROM 450-NS 3-S	34649	D2732
A3U10	04145-85026	4		IC NMOS 32768 (32K) EPROM 450-NS 3-S	34649	D2732
A3U11	04145-85037	4		IC NMOS 32768 (32K) EPROM 450-NS 3-S	34649	D2732
A3U12	1826-0013	8		IC OP AMP LOW-NOISE TO-99 PKG	06665	SSS741CJ
A3U13	1826-0497	2	1	IC COMPARATOR PRCN TO-99 PKG	27014	LF311H
A3U14	1826-0550	8	2	IC CONV 8-B-D/A 16-DIP-P PKG	07263	UA0801EPC
A3U16	1820-2738	6		IC-DEG AM2503PC	27014	DM2503CN
A3U17	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A3U18	1820-1991	1		IC CNTR TTL LS DECD DUAL 4-BIT	01295	SN74LS390N
A3U19	1820-1430	3		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS161AN
A3U20	1820-1202	7		IC GATE TTL LS NAND TPL 3-INP	01295	SN74LS10N
A3U21	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U22	1820-2099	2	1	IC MICPROC NMOS 8-BIT	04713	MC6802P
A3U23	1820-1416	5		IC SCHMITT-TRIG TTL LS INV HEX 1-INP	01295	SN74LS14N
A3U24	1818-0438	4	2	IC NMOS 4096 (4K) STAT RAM 450-NS 3-S	01295	TMS2114-45NL
A3U25	1818-0438	4		IC NMOS 4096 (4K) STAT RAM 450-NS 3-S	01295	TMS2114-45NL
A3U26	1826-0503	1	1	IC SMPL/HOLD TO-99 PKG	27014	LF398H
A3U27	1826-0319	7	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	04713	LF356G
A3U28	1820-1430	3		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS161AN
A3U29	1820-1460	9	1	IC MISC TTL QUAD	01295	SN74265N
A3U30	1820-1428	9	1	IC MUXR/DATA-SEL TTL LS 2-TO-1-LINE QUAD	01295	SN74LS158N
A3U31	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A3U32	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A3U33	1820-2075	4		IC MISC TTL LS	01295	SN74LS245N
A3U34	1820-1425	6		IC SCHMITT-TRIG TTL LS NAND QUAD 2-INP	01295	SN74LS132N
A3U35	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A3U36	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A3U37	1826-0602	1	1	IC MULTIPLXR 16-CHAN-ANLG 28-DIP-C PKG	24355	AD7506KD
A3U38	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A3U39	1820-1430	3		IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG	01295	SN74LS161AN
A3U40	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A3U41	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A3U42	1820-1216	3		IC DCDR TTL LS 3-TO-8-LINE 3-INP	01295	SN74LS138N
A3U43	1820-1645	2	1	IC BFR TTL LS BUS QUAD	01295	SN74LS126AN
A3U44	1820-2470	3	1	IC-DIGITAL MC6850P	28480	1820-2470
A3W1	1258-0141	8		JUMPER-REM	28480	1258-0141
A3W2	1258-0141	8		JUMPER-REM	28480	1258-0141
A3W3	1258-0141	8		JUMPER-REM	28480	1258-0141
A3W4	1258-0141	8		JUMPER-REM	28480	1258-0141
A3W5	1251-4787	2		SHUNT-DIP 8-POSITION	28480	1251-4787
A3W6	1258-0141	8		JUMPER-REM	28480	1258-0141
A3W7	1258-0141	8		JUMPER-REM	28480	1258-0141
A3W8	1258-0141	8		JUMPER-REM	28480	1258-0141
A3W9	1258-0141	8		JUMPER-REM	28480	1258-0141
A3Y1	0410-1378	8	1	CRYSTAL-3.84 MHZ	28480	0410-1378
	8159-0005			RESISTOR-ZERO OHMS 22 AWG LEAD DIA		
A4	04145-66504	5	1	D-A CONVERTER BOARD ASS'Y	28480	04145-66504
A4C1	0121-0105	4	10	CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C2	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C3	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C4	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C5	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C6	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C7	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C8	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C9	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C10	0121-0105	4		CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG	52763	304324 9/35PF N650
A4C11	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C12	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C13	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C14	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C15	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C16	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C17	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C18	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C19	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C20	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C21	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C22	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C23	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C24	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C25	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4C26	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C27	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C28	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C29	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C30	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C31	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C32	0160-2204	0		CAPACITOR-FXD 100PF +-5% 300VDC MICA	28480	0160-2204
A4C33	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A4C34	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C35	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C36	0160-5433	3	10	CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C37	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C38	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C39	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C40	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C41	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C42	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C43	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C44	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C45	0160-5433	3		CAPACITOR-FXD 0.1UF	28480	0160-5433
A4C46	0160-4830	8	10	CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C47	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C48	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C49	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C50	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C51	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C52	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C53	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C54	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C55	0160-4830	8		CAPACITOR-FXD 2200PF +-5% 100VDC CER	28480	0160-4810
A4C56	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A4C57	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A4C58	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A4C59	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A4C60	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C61	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C62	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C63	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C64	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C65	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C66	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C67	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C68	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C69	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C70	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C71	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C72	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C73	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C74	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C75	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C76	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A4C77	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C78	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C79	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A4C80	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A4C81	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A4C82	0160-4822	2		CAPACITOR-FXD 1000PF +-5% 100VDC CER	28480	0160-4822
A4C83	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C84	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C85	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C86	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A4C87	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A4C88	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A4C89	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A4C90	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4C91	0180-0229	7	1	CAPACITOR-FXD 33UF+-10% 10VDC TA	56289	150D336X9010B2
A4C92	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A4C93	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A4CR1	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR2	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4DS1	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A4DS2	1990-0486	6		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4684
A4J1	1200-0541	1		SOCKET-IC 24-CONT DIP DIP-SLDR	28480	1200-0541
A4J2	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4L1	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A4L2	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A4L3	9100-1788	6		CHOKE-WIDE BAND ZMAX=680 OHM@ 180 MHZ	02114	VK200 20/4B
A4L4	9100-3139	5		INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A4Q1	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A4Q2	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A4R1	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R2	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R3	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R4	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R5	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R6	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R7	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R8	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R9	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R10	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R11	2100-3354	9		RESISTOR-TRMR 50K 10% C SIDE-ADJ 1-TRN	28480	2100-3354
A4R12	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R13	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R14	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R15	0683-2225	3		RESISTOR 2.2K 5% .25W FC TC=-400/+700	01121	CB2225
A4R16	0683-2225	3		RESISTOR 2.2K 5% .25W FC TC=-400/+700	01121	CB2225
A4R17	0683-5645	7		RESISTOR 560K 5% .25W FC TC=-800/+900	01121	CB5645
A4R18	0683-3305	2	2	RESISTOR 33 5% .25W FC TC=-400/+500	01121	CB3305
A4R19	0683-3305	2		RESISTOR 33 5% .25W FC TC=-400/+500	01121	CB3305
A4R20	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R21	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R22	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R23	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R24	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R25	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R26	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R27	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R28	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R29	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A4R30	0699-0918	0		RESISTOR-22.65K OHM 0.1%	28480	0699-0918
A4R31	1810-0269	3		NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0269
A4R32	1810-0269	3		NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0269
A4R33	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R34	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R35	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R36	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R37	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R38	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R39	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R40	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R41	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R42	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A4R43	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R44	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R45	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R46	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R47	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R48	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R49	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R50	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R51	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R52	0683-1515	9		RESISTOR 150 5% .25W FC TC=-400/+700	01121	CB1035
A4R53	0699-0597	1		RESISTOR 2.26K .1% .125W F TC=0+-25	28480	0699-0597
A4R54	0699-0752	0		RESISTOR 1.78K .1% .125W F TC=0+-25	28480	0699-0752
A4R55	0757-0278	9		RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A4R56	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R57	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R58	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R59	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A4R60	0683-1005	5		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A4U1	1820-1374	4	5	IC SWITCH ANLG QUAD 16-DIP-P PKG	24355	AD7510DIJN
A4U2	1820-1374	4		IC SWITCH ANLG QUAD 16-DIP-P PKG	24355	AD7510DIJN
A4U3	1820-1374	4		IC SWITCH ANLG QUAD 16-DIP-P PKG	24355	AD7510DIJN
A4U4	1820-1374	4		IC SWITCH ANLG QUAD 16-DIP-P PKG	24355	AD7510DIJN
A4U5	1820-1374	4		IC SWITCH ANLG QUAD 16-DIP-P PKG	24355	AD7510DIJN
A4U6	1826-0668	9	1	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	04713	LF356AG
A4U7	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A4U8	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A4U9	1820-0495	8		IC DCDR TTL 4-TO-16-LINE 4-INP	01295	SN74154N
A4U10	1820-1429	0	1	IC CNTR TTL LS DECD SYNCHRO	01295	SN74LS160AN

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A4U11	1820-1194	6		IC CNTR TTL LS BIN UP/DOWN SYNCHRD	01295	SN74LS193N
A4U12	1826-0843	2	7	IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	07263	UAF772HC
A4U13	1826-0843	2		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	07263	UAF772HC
A4U14	1826-0843	2		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	07263	UAF772HC
A4U15	1826-0843	2		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	07263	UAF772HC
A4U16	1826-0843	2		IC OP AMP LOW-BIAS-H-IMPD TO-99 PKG	07263	UAF772HC
A4U17	1826-0013	8		IC OP AMP LOW-NOISE TO-99 PKG	06665	SSS741CJ
A4U18	1813-0251	9		IC-DAC 71-CSB-I	28480	1813-0251
A4U19	1820-0628	9	4	IC TTL 64-BIT STAT RAM 60-NS 0-C	01295	SN7489N
A4U20	1820-0628	9		IC TTL 64-BIT STAT RAM 60-NS 0-C	01295	SN7489N
A4U21	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A4U22	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A4U24	1826-0550	8		IC CONV 8-B-D/A 16-DIP-P PKG	07263	UA0801EPC
A4U25	1820-0628	9		IC TTL 64-BIT STAT RAM 60-NS 0-C	01295	SN7489N
A4U26	1820-0628	9		IC TTL 64-BIT STAT RAM 60-NS 0-C	01295	SN7489N
A4U27	1820-1989	7		IC CNTR TTL LS BIN DUAL 4-BIT	07263	74LS393PC
A4U28	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A4U29	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A4U30	1826-0416	5	3	IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13331D
A4U31	1826-0416	5		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13331D
A4U32	1826-0416	5		IC SWITCH ANLG QUAD 16-DIP-C PKG	27014	LF13331D
A4U33	1820-1962	6	1	IC DCDR CMOS BCD-TO-DEC	3L585	CD4028BE
A4U34	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A4U35	1820-1873	8	1	IC BFR TTL LS INV OCTL 2-INP	27014	DM81LS98N
A4U36	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A4U37	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A4U38	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A4U39	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A4U40	1820-1794	2		IC BFR TTL LS NON-INV OCTL	27014	DM81LS95N
A4U41	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N
A4W1	1258-0141	8		JUMPER-REM	28480	1258-0141
	0340-0092	2	32	TERMINAL-STUD SPCL-FDTHRU PRESS-MTG	28480	0340-0092
	0340-0060	4	20	TERMINAL-STUD SPCL-FDTHRU PRESS-MTG	98291	011-6809 000 209
	8150-3991	3	36	WIRE-ELECTRICAL		
A5	04145-66505	6	1	SMU BOARD ASS'Y (SHIELD COVERS ARE NOT INCLUDED)	28480	04145-66505
A5C1	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C2	0160-4795	8	2	CAPACITOR-FXD 4.7PF +-.5PF 100VDC CER	28480	0160-4795
A5C3	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C4	0140-0196	3		CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A5C5	0160-2261	9	2	CAPACITOR-FXD 15PF +-5% 500VDC CER 0+-30	28480	0160-2261
A5C6	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A5C7	0160-4834	6	2	CAPACITOR-FXD .047UF +-10% 100VDC CER	28480	0160-4834
A5C8	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C9	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A5C10	0160-4834	6		CAPACITOR-FXD .047UF +-10% 100VDC CER	28480	0160-4834
A5C11	0160-2254	0	1	CAPACITOR-FXD 7.5PF +-.25PF 500VDC CER	28480	0160-2254
A5C12	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C13	0160-2199	2	3	CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A5C14	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A5C15	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A5C16	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C17	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C18	0160-0363	8	1	CAPACITOR-FXD 620PF +-5% 300VDC MICA	28480	0160-0363
A5C19	0160-2199	2		CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A5C20	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A5C21	0160-2199	2		CAPACITOR-FXD 30PF +-5% 300VDC MICA	28480	0160-2199
A5C22	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C23	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A5C24	0160-0161	4	6	CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A5C25	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A5C26	0170-0040	9	2	CAPACITOR-FXD .047UF +-10% 200VDC POLYE	56289	292P47392
A5C27	0170-0040	9		CAPACITOR-FXD .047UF +-10% 200VDC POLYE	56289	292P47392
A5C28	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C29	0160-4795	8		CAPACITOR-FXD 4.7PF +-.5PF 100VDC CER	28480	0160-4795
A5C30	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C31	0140-0196	3		CAPACITOR-FXD 150PF +-5% 300VDC MICA	72136	DM15F151J0300WV1CR
A5C32	0160-2261	9		CAPACITOR-FXD 15PF +-5% 500VDC CER 0+-30	28480	0160-2261
A5C33	0160-4805	1	2	CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30	28480	0160-4805
A5C34	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A5C35	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5C36	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C37	0160-0160	3	1	CAPACITOR-FXD 8200PF +-10% 200VDC POLYE	28480	0160-0160
A5C38	0160-4574	1	4	CAPACITOR-FXD 1000PF +-10% 100VDC CER	28480	0160-4574
A5C39	0180-1066	2	5	CAPACITOR, FXD 47 MF AL	28480	0180-1066
A5C40	0180-1066	2		CAPACITOR, FXD 47 MF AL	28480	0180-1066
A5C41	0180-1066	2		CAPACITOR, FXD 47 MF AL	28480	0180-1066
A5C42	0160-4574	1		CAPACITOR-FXD 1000PF +-10% 100VDC CER	28480	0160-4574
A5C43	0160-4574	1		CAPACITOR-FXD 1000PF +-10% 100VDC CER	28480	0160-4574
A5C44	0180-1085	5	1	CAPACITOR-FXD 4.7UF 16VDC TA	28480	0180-1085
A5C45	0160-1688	2	1	CAPACITOR-FXD 2PF 5% 125VDC	28480	0160-1688
A5C46	0160-0155	6	2	CAPACITOR-FXD 3300PF +-10% 200VDC POLYE	28480	0160-0155
A5C47	0160-0155	6		CAPACITOR-FXD 3300PF +-10% 200VDC POLYE	28480	0160-0155
A5C48	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A5C49	0180-1066	2		CAPACITOR, FXD 47 MF AL	28480	0180-1066
A5C50	0180-1066	2		CAPACITOR, FXD 47 MF AL	28480	0180-1066
A5C51	0160-4830	2	3	CAPACITOR-FXD 2200PF +-10% 100VDC CER	28480	0160-4830
A5C52	0160-4830	2		CAPACITOR-FXD 2200PF +-10% 100VDC CER	28480	0160-4830
A5C53	0160-4830	2		CAPACITOR-FXD 2200PF +-10% 100VDC CER	28480	0160-4830
A5C54	0160-4802	8	1	CAPACITOR-FXD 82PF +-5% 100VDC CER 0+-30	28480	0160-4802
A5C55	0160-4792	5	1	CAPACITOR-FXD 8.2PF +-.5PF 100VDC CER	28480	0160-4792
A5C56	0160-4805	1		CAPACITOR-FXD 47PF +-5% 100VDC CER 0+-30	28480	0160-4805
A5C57	0160-5064	6	1	CAPACITOR-FXD	28480	0160-5064
A5C58	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5C59	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A5C60	0160-4833	5	4	CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A5C61	0160-4833	5		CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A5C62	0160-4833	5		CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A5C63	0160-4833	5		CAPACITOR-FXD .022UF +-10% 100VDC CER	28480	0160-4833
A5C64	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A5CP1	1990-0444	6		OPTO-ISOLATOR LED-PDIO/XSTR IF=25MA-MAX	28480	6N136
A5CP2	1990-0444	6		OPTO-ISOLATOR LED-PDIO/XSTR IF=25MA-MAX	28480	6N136
A5CP3	1990-0444	6		OPTO-ISOLATOR LED-PDIO/XSTR IF=25MA-MAX	28480	6N136
A5CR1	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR2	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR3	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR4	1901-0376	6	16	DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR5	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR6	1902-3122	8	2	DIODE-ZNR 6.65V 2% DO-35 PD=.4W	28480	1902-3122
A5CR7	1901-0033	2	27	DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A5CR8	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR9	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR10	1902-3105	7	3	DIODE-ZNR 5.62V 2% DO-35 PD=.4W	28480	1902-3105
A5CR11	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR12	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR13	1902-3114	8	2	DIODE-ZNR 6.19V 2% DO-35 PD=.4W	28480	1902-3114
A5CR14	1902-3105	7		DIODE-ZNR 5.62V 2% DO-35 PD=.4W	28480	1902-3105
A5CR15	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR16	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR17	1902-3114	8		DIODE-ZNR 6.19V 2% DO-35 PD=.4W	28480	1902-3114
A5CR18	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR19	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR20	1901-0460	9	4	DIODE-STABISTOR 30V 150MA DO-7	28480	1901-0460
A5CR21	1901-0025	2	16	DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A5CR22	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A5CR23	1901-0460	9		DIODE-STABISTOR 30V 150MA DO-7	28480	1901-0460
A5CR24	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR25	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR26	1901-0460	9		DIODE-STABISTOR 30V 150MA DO-7	28480	1901-0460
A5CR27	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A5CR28	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR29	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR30	1901-0460	9		DIODE-STABISTOR 30V 150MA DO-7	28480	1901-0460
A5CR31	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR32	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR33	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR34	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR35	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR36	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR37	1902-3122	8		DIODE-ZNR 6.65V 2% DO-35 PD=.4W	28480	1902-3122
A5CR38	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A5CR39	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR40	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR41	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR42	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR43	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A5CR44	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A5CR45	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5CR46	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR47	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR48	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR49	1902-3059	0	2	DIODE-ZNR 3.83V 5% DO-35 PD=.4W	28480	1902-3059
A5CR50	1902-3059	0		DIODE-ZNR 3.83V 5% DO-35 PD=.4W	28480	1902-3059
A5CR51	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A5CR52	1901-0518	8		DIODE-SM SIG SCHOTTKY	28480	1901-0518
A5CR53	1902-3205	8	2	DIODE-ZNR 15V 5% DO-35 PD=.4W TC=+.057%	28480	1902-3205
A5CR54	1902-3205	8		DIODE-ZNR 15V 5% DO-35 PD=.4W TC=+.057%	28480	1902-3205
A5CR55	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR56	1901-0376	6		DIODE-GEN PRP 35V 50MA DO-35	28480	1901-0376
A5CR57	1902-3182	0	3	DIODE-ZNR 12.1V 5% DO-35 PD=.4W	28480	1902-3182
A5CR58	1902-3182	0		DIODE-ZNR 12.1V 5% DO-35 PD=.4W	28480	1902-3182
A5CR59	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR60	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A5CR61	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR62	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR63	1902-3182	0		DIODE-ZNR 12.1V 5% DO-35 PD=.4W	28480	1902-3182
A5CR64	1901-0040	1		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A5CR65	1902-0184	6	1	DIODE-ZNR 16.2V 5% DO-35 PD=.4W	28480	1902-0184
A5CR66	1902-3105	7		DIODE-ZNR 5.62V 2% DO-35 PD=.4W	28480	1902-3105
A5J1	1251-7406	8	8	CONNECTOR-10-PIN MALE	28480	1251-7406
A5J2	1250-1368	7	1	CONNECTOR-RF SMB M PC 50-OHM	28480	1250-1368
A5J3	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A5J4	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A5K1	0490-1137	5	6	RELAY-REED 1A	28480	0490-1137
A5K2	0490-1137	5		RELAY-REED 1A	28480	0490-1137
A5K3	0490-1137	5		RELAY-REED 1A	28480	0490-1137
A5K4	0490-1137	5		RELAY-REED 1A	28480	0490-1137
A5K5	0490-1325	3	3	RELAY-REED	28480	0490-1325
A5K6	0490-1325	3		RELAY-REED	28480	0490-1325
A5K7	0490-1325	3		RELAY-REED	28480	0490-1325
A5K8	0490-1326	4	1	RELAY-REED	28480	0490-1326
A5L1	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A5L2	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A5L3	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A5L4	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A5L5	9140-0114	4		INDUCTOR RF-CH-MLD 10UH 10% .166DX.385LG	28480	9140-0114
A5Q1	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q2	1854-0810	2	11	TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q3	1855-0414	4	8	TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q4	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q5	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q6	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q7	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q8	1854-0474	4	3	TRANSISTOR NPN SI PD=310MW FT=100MHZ	04713	2N5551
A5Q9	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q10	1853-0336	5	1	TRANSISTOR PNP SI PD=625MW FT=50MHZ	04713	MPSA92
A5Q11	1854-0637	1	1	TRANSISTOR NPN 2N2219A SI TO-5 PD=800MW	01295	2N2219A
A5Q12	1853-0314	9	1	TRANSISTOR PNP 2N2905A SI TO-39 PD=600MW	04713	2N2905A
A5Q13	1855-0386	9	4	TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392
A5Q14	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q15	1854-0575	6	2	TRANSISTOR NPN SI PD=625MW FT=50MHZ	04713	MPS-A42
A5Q16	1854-0575	6		TRANSISTOR NPN SI PD=625MW FT=50MHZ	04713	MPS-A42
A5Q17	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A5Q18	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q19	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q20	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q21	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q22	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5Q23	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q24	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q25	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q26	1855-0280	2	2	TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	17856	E107
A5Q27	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q28	1855-0280	2		TRANSISTOR J-FET N-CHAN D-MODE TO-92 SI	17856	E107
A5Q29	1855-0414	4		TRANSISTOR J-FET 2N4393 N-CHAN D-MODE	04713	2N4393
A5Q30	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392
A5Q31	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392
A5Q32	1855-0386	9		TRANSISTOR J-FET 2N4392 N-CHAN D-MODE	04713	2N4392
A5Q33	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A5R1	0683-3355	2	2	RESISTOR 3.3M 5% .25W FC TC=-900/+1100	01121	CB3355
A5R2	0683-3325	6	4	RESISTOR 3.3K 5% .25W FC TC=-400/+700	01121	CB3325
A5R3	0683-1015	7		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A5R4	0683-3925	2		RESISTOR 3.9K 5% .25W FC TC=-400/+700	01121	CB3925
A5R5	0683-4745	6	3	RESISTOR 470K 5% .25W FC TC=-800/+900	01121	CB4745

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5R6	0699-0912	4	4	RESISTOR-100K OHM 0.01%	28480	0699-0912
A5R7	0699-0912	4		RESISTOR-100K OHM 0.01%	28480	0699-0912
A5R8	0683-3915	0	3	RESISTOR 390 5% .25W FC TC=-400/+600	01121	CB3915
A5R9	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A5R10	0683-1065	7	8	RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A5R11	0683-3315	4		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A5R12	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A5R13	0683-2725	8		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A5R14	0683-6825	7	8	RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A5R15	0683-7515	4	2	RESISTOR 750 5% .25W FC TC=-400/+600	01121	CB7515
A5R16	0683-2725	8		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A5R17	0683-6825	7		RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A5R18	0683-7515	4		RESISTOR 750 5% .25W FC TC=-400/+600	01121	CB7515
A5R19	0683-1005	5		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A5R20	0683-3315	4		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A5R21	0699-0909	9	2	RESISTOR-100K OHM 0.01%	28480	0699-0909
A5R22	0699-0910	2	4	RESISTOR-50K OHM 0.01%	28480	0699-0910
A5R23	0699-0910	2		RESISTOR-50K OHM 0.01%	28480	0699-0910
A5R24	0699-0911	3	2	RESISTOR-16.6666K OHM	28480	0699-0911
A5R25	0683-1015	7		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A5R26	0683-3325	6		RESISTOR 3.3K 5% .25W FC TC=-400/+700	01121	CB3325
A5R27	0683-4715	0		RESISTOR 470 5% .25W FC TC=-400/+600	01121	CB4715
A5R28	0757-0465	6	2	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R29	0683-2255	9	1	RESISTOR 2.2M 5% .25W FC TC=-900/+1100	01121	CB2255
A5R30	0683-4745	6		RESISTOR 470K 5% .25W FC TC=-800/+900	01121	CB4745
A5R31	0683-1225	1	5	RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A5R32	0683-3315	4		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A5R33	0683-4705	8	4	RESISTOR 47 5% .25W FC TC=-400/+500	01121	CB4705
A5R34	0683-4705	8		RESISTOR 47 5% .25W FC TC=-400/+500	01121	CB4705
A5R35	0683-0335	2	8	RESISTOR 3.3 5% .25W FC TC=-400/+500	01121	CB33G5
A5R36	0683-5605	9	2	RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A5R37	0683-0335	2		RESISTOR 3.3 5% .25W FC TC=-400/+500	01121	CB33G5
A5R38	0683-5605	9		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A5R39	0698-4444	3	3	RESISTOR 4.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4871-F
A5R40	0683-5645	7		RESISTOR 560K 5% .25W FC TC=-800/+900	01121	CB5645
A5R41	0683-4705	8		RESISTOR 47 5% .25W FC TC=-400/+500	01121	CB4705
A5R42	0683-4705	8		RESISTOR 47 5% .25W FC TC=-400/+500	01121	CB4705
A5R43	0683-1065	7		RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A5R44	0683-1055	5	3	RESISTOR 1M 5% .25W FC TC=-800/+900	01121	CB1055
A5R45	0683-6815	5		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A5R46	0683-3915	0		RESISTOR 390 5% .25W FC TC=-400/+600	01121	CB3915
A5R47	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A5R48	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A5R49	0683-3355	2		RESISTOR 3.3M 5% .25W FC TC=-900/+1100	01121	CB3355
A5R50	0683-3325	6		RESISTOR 3.3K 5% .25W FC TC=-400/+700	01121	CB3325
A5R51	0683-1015	7		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A5R52	0683-3925	2		RESISTOR 3.9K 5% .25W FC TC=-400/+700	01121	CB3925
A5R53	0683-1245	5	1	RESISTOR 120K 5% .25W FC TC=-800/+900	01121	CB1245
A5R54	0699-0912	4		RESISTOR-100K OHM 0.01%	28480	0699-0912
A5R55	0699-0912	4		RESISTOR-100K OHM 0.01%	28480	0699-0912
A5R56	0683-3915	0		RESISTOR 390 5% .25W FC TC=-400/+600	01121	CB3915
A5R57	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A5R58	0683-1065	7		RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A5R59	0683-3315	4		RESISTOR 330 5% .25W FC TC=-400/+600	01121	CB3315
A5R60	1810-0604	5	1	RESISTIVE NETWORK	28480	5080-3062
A5R61	0757-0465	6		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A5R62	0757-0288	1	1	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A5R63	0699-0909	9		RESISTOR-100K OHM 0.01%	28480	0699-0909
A5R64	0699-0910	2		RESISTOR-50K OHM 0.01%	28480	0699-0910
A5R65	0699-0910	2		RESISTOR-50K OHM 0.01%	28480	0699-0910
A5R66	0699-0911	3		RESISTOR-16.6666K OHM	28480	0699-0911
A5R67	0683-1835	9	1	RESISTOR 18K 5% .25W FC TC=-400/+800	01121	CB1835
A5R68	0698-3157	3	1	RESISTOR 19.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1962-F
A5R69	0683-5635	5	7	RESISTOR 56K 5% .25W FC TC=-400/+800	01121	CB5635
A5R70	0683-3945	6		RESISTOR 390K 5% .25W FC TC=-800/+900	01121	CB3945
A5R71	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R72	0683-5635	5		RESISTOR 56K 5% .25W FC TC=-400/+800	01121	CB5635
A5R73	0683-3945	6		RESISTOR 390K 5% .25W FC TC=-800/+900	01121	CB3945
A5R74	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R75	0699-0913	5	3	RESISTOR-10K OHM 0.01%	28480	0699-0913
A5R76	0699-0913	5		RESISTOR-10K OHM 0.01%	28480	0699-0913
A5R77	0698-4444	3		RESISTOR 4.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4871-F
A5R78	0757-1094	9	1	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A5R79	0698-4497	6	1	RESISTOR 48.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4872-F
A5R80	0683-4745	6		RESISTOR 470K 5% .25W FC TC=-800/+900	01121	CB4745

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5R81	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A5R82	0683-4725	2	6	RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A5R83	0683-4725	2		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A5R84	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A5R85	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A5R86	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A5R87	0683-6845	1	2	RESISTOR 680K 5% .25W FC TC=-800/+900	01121	CB6845
A5R88	0683-1015	7		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A5R89	0683-2235	5		RESISTOR 22K 5% .25W FC TC=-400/+800	01121	CB2235
A5R90	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A5R91	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A5R92	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A5R93	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A5R94	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A5R95	0683-6845	1		RESISTOR 680K 5% .25W FC TC=-800/+900	01121	CB6845
A5R96	0683-2245	7	3	RESISTOR 220K 5% .25W FC TC=-800/+900	01121	CB2245
A5R97	0683-1065	7		RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A5R98	0683-1065	7		RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A5R99	0683-2245	7		RESISTOR 220K 5% .25W FC TC=-800/+900	01121	CB2245
A5R100	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A5R101	0683-1045	3		RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A5R102	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A5R103	0683-1045	3		RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A5R104	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A5R105	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A5R106	0683-6815	5		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A5R107	0683-6815	5		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A5R108	0683-6815	5		RESISTOR 680 5% .25W FC TC=-400/+600	01121	CB6815
A5R109	0683-2245	7		RESISTOR 220K 5% .25W FC TC=-800/+900	01121	CB2245
A5R110	0683-1045	3		RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A5R111	0683-1045	3		RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A5R112	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A5R113	0683-1045	3		RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A5R114	0757-0401	0	1	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A5R115	0683-3325	6		RESISTOR 3.3K 5% .25W FC TC=-400/+700	01121	CB3325
A5R116	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A5R117	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A5R118	0683-1055	5		RESISTOR 1M 5% .25W FC TC=-800/+900	01121	CB1055
A5R119	0699-0913	5		RESISTOR-10K OHM 0.01%	28480	0699-0913
A5R120	0699-0915	7	1	RESISTOR-1.11111K OHM	28480	0699-0915
A5R121	0699-0907	7	1	RESISTOR-1 G	28480	0699-0907
A5R122	0757-0280	3	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A5R123	0683-1045	3		RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A5R124	0683-1045	3		RESISTOR 100K 5% .25W FC TC=-400/+800	01121	CB1045
A5R125	0698-6369	5	1	RESISTOR 1M .1% .25W F TC=0+-25	28480	0698-6369
A5R126	0683-2235	5		RESISTOR 22K 5% .25W FC TC=-400/+800	01121	CB2235
A5R127	0683-2235	5		RESISTOR 22K 5% .25W FC TC=-400/+800	01121	CB2235
A5R128	0683-2235	5		RESISTOR 22K 5% .25W FC TC=-400/+800	01121	CB2235
A5R129	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R130	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R131	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R132	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R133	0699-0916	8	1	RESISTOR-1.00045K OHM	28480	0699-0916
A5R134	0699-0908	8	1	RESISTOR-10.0013	28480	0699-0908
A5R135	0699-0914	6	1	RESISTOR-100.975K OHM	28480	0699-0914
A5R136	0699-0906	6	1	RESISTOR-10.1 MEGOHM	28480	0699-0906
A5R137	0683-1055	5		RESISTOR 1M 5% .25W FC TC=-800/+900	01121	CB1055
A5R138	0683-1065	7		RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A5R139	0683-1065	7		RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A5R140	0683-1065	7		RESISTOR 10M 5% .25W CC TC=-900/+1100	01121	CB1065
A5R141	0683-1525	4		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A5R142	0683-1545	8	4	RESISTOR 150K 5% .25W FC TC=-800/+900	01121	CB1545
A5R143	0683-1545	8		RESISTOR 150K 5% .25W FC TC=-800/+900	01121	CB1545
A5R144	0683-1545	8		RESISTOR 150K 5% .25W FC TC=-800/+900	01121	CB1545
A5R145	0683-1545	8		RESISTOR 150K 5% .25W FC TC=-800/+900	01121	CB1545
A5R146	0683-8225	5	1	RESISTOR 8.2K 5% .25W FC TC=-400/+700	01121	CB8225
A5R147	0683-1525	4		RESISTOR 1.5K 5% .25W FC TC=-400/+700	01121	CB1525
A5R148	0683-1535	6	4	RESISTOR 15K 5% .25W FC TC=-400/+800	01121	CB1535
A5R149	0683-1535	6		RESISTOR 15K 5% .25W FC TC=-400/+800	01121	CB1535
A5R150	0683-1535	6		RESISTOR 15K 5% .25W FC TC=-400/+800	01121	CB1535
A5R151	0683-1535	6		RESISTOR 15K 5% .25W FC TC=-400/+800	01121	CB1535
A5R152	0683-4725	2		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A5R153	0683-4725	2		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A5R154	0683-4725	2		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725
A5R155	0683-4725	2		RESISTOR 4.7K 5% .25W FC TC=-400/+700	01121	CB4725

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A5R156	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R157	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R158	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R159	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A5R160	0683-2725	8		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A5R161	0683-3335	8		RESISTOR 33K 5% .25W FC TC=-400/+800	01121	CB3335
A5U1	1826-0908	0	3	IC-LIN 351BH	27014	LF351BH
A5U2	1826-0908	0		IC-LIN 351BH	27014	LF351BH
A5U3	1826-0908	0		IC-LIN 351BH	27014	LF351BH
A5U4	1826-0686	9	1	IC-LIN 3528AM	8E175	3528AM
A5U5	1826-0843	2		IC-LIN LF353BH	07263	UAF772HC
A5U6	1826-0843	2		IC-LIN LF353BH	07263	UAF772HC
A5U7	1858-0049	7	2	TRANSISTOR ARRAY 16-PIN PLSTC DIP	28480	1858-0049
A5U8	1826-0065	0	1	IC COMPARATOR PRCN 8-DIP-P PKG	S0545	UPC311C
A5U9	1820-1858	9		IC FF TTL LS D-TYPE OCTL	01295	SN74LS377N
A5U10	1820-1641	8	1	IC DRVR TTL LS BUS DRVR HEX 1-INP	01295	SN74LS365AN
A5U11	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A5U12	1826-0686	1		IC-LIN LF351AH	27014	LF351AH
A5U13	1826-0686	1		IC-LIN LF351AH	27014	LF351AH
A5U14	1826-1009	9		IC-LIN 3528AM	8E175	3528AM
A5U15	1858-0049	7		TRANSISTOR ARRAY 16-PIN PLSTC DIP	28480	1858-0049
A5U16	1820-1662	3	2	IC SHF-RGTR CMOS SERIAL-IN PRL-OUT 8-BIT	31585	CD4094BE
A5U17	1820-1662	3		IC SHF-RGTR CMOS SERIAL-IN PRL-OUT 8-BIT	31585	CD4094BE
A5U18	1858-0077	1	1	TRANSISTOR ARRAY 14-PIN PLSTC TO-116	04713	MPQ2222P
A5U19	1858-0076	0	1	TRANSISTOR ARRAY 14-PIN PLSTC TO-116	04713	MPQ2907P
A5W1	1258-0141	8		JUMPER-REM	28480	1258-0141
A5W2	1258-0141	8		JUMPER-REM	28480	1258-0141
	0340-0060	4		TERMINAL-STUD SPCL-FDTHRU PRESS-MTG	98291	011-6809 000 209
	0340-0092	2		TERMINAL-STUD SPCL-FDTHRU PRESS-MTG	28480	0340-0092
	8159-0005	0	7	RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
	04145-00613	9	1	SHIELD-COVER (PATTERN SIDE)	28480	04145-00613
	04145-00614	0	1	SHIELD-COVER (COMPONENT SIDE)	28480	04145-00614
A9	04145-66509	0	1	HP-IB AND MSU CONTROL BOARD ASS'Y	28480	04145-66509
A9C1	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A9C2	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A9C3	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A9C4	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A9C5	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A9C6	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A9C7	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A9C8	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A9C9	0160-2201	7	1	CAPACITOR-FXD 51PF +-5% 300VDC MICA	28480	0160-2201
A9C10	0180-0197	8		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A9C11	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A9C12	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A9J1	0360-1901	6		CABLE TRANSITION	28480	0360-1901
A9J2	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A9J4	1200-0654	7		SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A9J5	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A9J6	1200-0654	7		SOCKET-IC 40-CONT DIP DIP-SLDR	28480	1200-0654
A9J8	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A9J9	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A9J10	1251-4822	6		CONNECTOR 3-PIN M POST TYPE	28480	1251-4822
A9L1	9100-3139	5		INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A9R1	1810-0269	3		NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0269
A9R2	0683-1515	2	7	RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A9R3	0683-1515	2		RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A9R4	0683-1515	2		RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A9R5	0683-1515	2		RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A9R6	0683-1515	2		RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A9R7	0757-0442	9	2	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A9R8	0698-3449	6	1	RESISTOR 28.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2872-F
A9R9	1810-0269	3		NETWORK-RES 9-SIP10.0K OHM X 8	28480	1810-0269
A9U1	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A9U2	1820-0621	2	2	IC BFR TTL NAND QUAD 2-INP	01295	SN7438N
A9U3	1820-2631	8	1	IC-DIGITAL MB8866	28480	1820-2631
A9U4	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A9U5	1820-1198	0	1	IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS03N
A9U6	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N
A9U7	1820-2549	7	1	IC-8291A P HPIB	28480	1820-2549
A9U8	1820-2058	3	4	IC MISC TTL S QUAD	07263	MC3448AL
A9U9	1820-2058	3		IC MISC TTL S QUAD	07263	MC3448AL
A9U10	1820-0621	2		IC BFR TTL NAND QUAD 2-INP	01295	SN7438N

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A9U11	1820-1281	2		IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS139N
A9U12	1820-2058	3		IC MISC TTL S QUAD	07263	MC3448AL
A9U13	1820-2058	3		IC MISC TTL S QUAD	07263	MC3448AL
A9U14	1820-1053	6	1	IC SCHMITT-TRIG TTL INV HEX	01295	SN7414N
A9U15	1820-1437	0	2	IC MV TTL LS MONOSTBL DUAL	01295	SN74LS221N
A9U16	1820-1194	6		IC CNTR TTL LS BIN UP/DOWN SYNCHRO	01295	SN74LS193N
A9U17	1820-1443	8	2	IC CNTR TTL LS BIN ASYNCHRO	01295	SN74LS293N
A9U18	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A9U19	1820-2024	3		IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS244N
A9W1	1258-0141	8		JUMPER-REM	28480	1258-0141
A9W2	1258-0141	8		JUMPER-REM	28480	1258-0141
A9W3	1258-0141	8		JUMPER-REM	28480	1258-0141
A9W4	1258-0141	8		JUMPER-REM	28480	1258-0141
A9W5	1258-0141	8		JUMPER-REM	28480	1258-0141
A9W6	8159-0005	0		RESISTOR-ZERO OHMS 22 AWG LEAD DIA	28480	8159-0005
A9W7	04145-61620	6	1	CABLE ASSEMBLY	28480	04145-61620
A10	04145-66510	3	1	KEYBOARD AND DISPLAY CONTROL BOARD ASS'Y	28480	04145-66510
A10C1	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A10C2	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A10C3	0180-0228	6		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A10C4	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A10C5	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A10C6	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A10C7	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A10C8	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A10C9	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A10DS1	1990-0487	7	5	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584
A10DS2	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584
A10DS3	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584
A10DS4	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584
A10DS5	1990-0670	0	8	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0670
A10DS6	1990-0670	0		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0670
A10DS7	1990-0670	0		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0670
A10DS8	1990-0670	0		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0670
A10DS9	1990-0670	0		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0670
A10DS10	1990-0670	0		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0670
A10DS11	1990-0487	7		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	5082-4584
A10DS12	1990-0670	0		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0670
A10DS13	1990-0665	3	1	LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0665
A10DS14	1990-0670	0		LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V	28480	1990-0670
A10DS15	1990-0517	4	1	LED-LAMP LUM-INT=3MCD IF=20MA-MAX BVR=5V	28480	5082-4655
A10R1	1810-0279	5	2	NETWORK-RES 10-SIP4.7K OHM X 9	01121	210A472
A10R2	1810-0283	1	2	NETWORK-RES 16-DIP270.0 OHM X 8	28480	1810-0283
A10R3	1810-0283	1		NETWORK-RES 16-DIP270.0 OHM X 8	28480	1810-0283
A10R4	1810-0279	5		NETWORK-RES 10-SIP4.7K OHM X 9	01121	210A472
A10S1-S66	5060-9436	7	66	PUSHBUTTON SWITCH P.C. MOUNT	28480	5060-9436
A10U1	1820-1207	2	1	IC GATE TTL LS NAND 8-INP	01295	SN74LS30N
A10U2	1820-1199	1		IC INV TTL LS HEX 1-INP	01295	SN74LS04N
A10U3	1820-1112	8		IC FF TTL LS D-TYPE POS-EDGE-TRIG	01295	SN74LS74AN
A10U4	1820-2096	9	1	IC CNTR TTL LS BIN DUAL 4-BIT	01295	SN74LS393N
A10U5	1820-1461	0	2	IC FF TTL D-TYPE POS-EDGE-TRIG CLEAR	01295	SN74273
A10U6	1820-1461	0		IC FF TTL D-TYPE POS-EDGE-TRIG CLEAR	01295	SN74273
A10U7	1820-1208	3		IC GATE TTL LS OR QUAD 2-INP	01295	SN74LS32N
A10U8	1820-1197	9		IC GATE TTL LS NAND QUAD 2-INP	01295	SN74LS00N
A10U9	1820-1473	4	1	IC ENCDR TTL 8-INP	01295	SN74148N
A10U10	1820-1443	8		IC CNTR TTL LS BIN ASYNCHRO	01295	SN74LS293N
A10U11	1820-1427	8	1	IC DCDR TTL LS 2-TO-4-LINE DUAL 2-INP	01295	SN74LS156N
	04145-61618	2	1	CABLE ASSEMBLY	28480	04145-61618
	5041-0059	2	4	KEY CAP-PALM-BRN-PRL	28480	5041-0059
	5041-0063	8	1	KEY CAP-PALM-BRN-PRL	28480	5041-0063
	5041-0277	6	21	KEY CAP-PRL	28480	5041-0277
	5041-0286	7	8	KEY CAP-HALF, L-PRL	28480	5041-0286
	5041-0343	7	13	KEY CAP-HALF	28480	5041-0343
	5041-0376	6	4	KEY CAP-HALF	28480	5041-0376
	5041-0451	8	1	KEY CAP-HALF	28480	5041-0451
	5041-0475	6	1	KEY CAP-HALF	28480	5041-0475
	5041-0508	6	1	KEY CAP-HALF	28480	5041-0508
	5041-0808	9	1	KEY CAP-HALF,SMOKE-SMST	28480	5041-0808
	5041-0811	4	1	KEY CAP-HALF,SMOKE-SMST	28480	5041-0811
	5041-0812	5	1	KEY CAP-HALF,SMOKE-SMST	28480	5041-0812
	5041-0813	6	1	KEY CAP-HALF,SMOKE-SMST	28480	5041-0813
	5041-0814	7	1	KEY CAP-HALF,SMOKE-SMST	28480	5041-0814
	5041-0815	8	1	KEY CAP-HALF,SMOKE-SMST	28480	5041-0815

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	5041-0816	9	2	KEY CAP-HALF,SMOKE-SMST	28480	5041-0816
	5041-0817	0	1	KEY CAP-HALF,SMOKE-SMST	28480	5041-0817
	5041-0818	1	1	KEY CAP-HALF,SMOKE-SMST	28480	5041-0818
	5041-0819	2	1	KEY CAP	28480	5041-0819
	5041-1881	0	1	KEY CAP-HALF	28480	5041-1881
	2950-0001			NUT-HEX-DBL-CHAM		
	5060-9444	7	1	ROTARY PULSE GENERATOR	28480	5060-9444
	04191-40002	0	1	INSULATOR	28480	04191-40002
	04262-25003	5	1	INSULATOR	28480	04262-25003
	5040-3322	6	1	INSULATOR	28480	5040-3322
	2190-0016			WSHR-LK INTL T		
A11	04145-66511	4	1	SWITCHING POWER SUPPLY BOARD ASS'Y (COMPONENT SIDE SHIELD COVER IS NOT INCLUDED)	28480	04145-66511
A11C1	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A11C2	0180-1050	4	1	CAPACITOR-FXD 100UF 25VDC	28480	0180-1050
A11C3	0180-3184	9	3	CAPACITOR-FXD 2200UF 35VDC AL	28480	0180-3184
A11C4	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A11C5	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A11C6	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A11C7	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A11C8	0180-3168	9	2	CAPACITOR-FXD 10UF 250VDC AL	28480	0180-3168
A11C9	0180-3168	9		CAPACITOR-FXD 10UF 250VDC AL	28480	0180-3168
A11C10	0160-3969	6	2	CAPACITOR-FXD .015UF +-20PF 250VAC(RMS)	28480	0160-3969
A11C11	0160-3969	6		CAPACITOR-FXD .015UF +-20PF 250VAC(RMS)	28480	0160-3969
A11C12	0180-3179	2	2	CAPACITOR-FXD 220UF 200VDC	28480	0180-3179
A11C13	0180-3179	2		CAPACITOR-FXD 220UF 200VDC	28480	0180-3179
A11C14	0160-4824	4	1	CAPACITOR-FXD 680PF +-5% 100VDC CER	28480	0160-4824
A11C15	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A11C16	0180-1704	5	1	CAPACITOR-FXD 47UF+-10% 6VDC TA	56289	150D476X9006B2
A11C17	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A11C18	0160-3456	6	1	CAPACITOR-FXD 1000PF +-10% 1KVDC CER	28480	0160-3456
A11C19	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A11C20	0160-4593	4	1	CAPACITOR-FXD 1.5UF +-20% 400VDC	28480	0160-4593
A11C21	0160-4574	1		CAPACITOR-FXD 1000PF +-10% 100VDC CER	28480	0160-4574
A11CP1	1990-0444	6		OPTO-ISOLATOR LED-PDIO/XSTR IF=25MA-MAX	28480	6N136
A11CP2	1990-0663	1	2	OPTO-ISOLATOR LED-PXSTR IF=40MA-MAX	28480	1990-0663
A11CP3	1990-0663	1		OPTO-ISOLATOR LED-PXSTR IF=40MA-MAX	28480	1990-0663
A11CR1	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A11CR2	1906-0051	4	3	DIODE-FW BRDG 100V 1A	28480	1906-0051
A11CR3	1906-0080	9	1	DIODE-FW BRDG 600V 10A	28480	1906-0080
A11CR4	1906-0051	4		DIODE-FW BRDG 100V 1A	28480	1906-0051
A11CR5	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A11CR6	1901-1065	2	2	DIODE-PWR RECT 1N4936 400V 1A 200NS	14936	1N4936
A11CR7	1901-1065	2		DIODE-PWR RECT 1N4936 400V 1A 200NS	14936	1N4936
A11F1	2110-0663		1	FUSE-THERMAL		
	2110-0269	0	6	FUSEHOLDER-CLIP TYPE.250-FUSE	28480	2110-0269
A11F2	2110-0304	4	1	FUSE 1.5A 250V TD 1.25X.25 UL	28480	2110-0304
A11F3	2110-0381	7	1	FUSE 3A 250V TD 1.25X.25	28480	2110-0381
A11J1	1251-4246	8	2	CONNECTOR 3-PIN M POST TYPE	28480	1251-4246
A11J2	1251-4246	8		CONNECTOR 3-PIN M POST TYPE	28480	1251-4246
A11J3	1251-7406	8		CONNECTOR-10 PIN MALE	28480	1251-7406
A11J4	1251-7406	8		CONNECTOR-10 PIN MALE	28480	1251-7406
A11J5	1251-7463	7	4	CONNECTOR-12 PIN MALE	28480	1251-7463
A11J6	1251-3837	1	1	CONNECTOR 4-PIN M UTILITY	28480	1251-3837
A11K1	0490-1312	8	1	RELAY	28480	0490-1312
A11L1	9140-0401	2	2	COIL-FXD 64 UH	28480	9140-0401
A11L2	9140-0401	2		COIL-FXD 64 UH	28480	9140-0401
A11L3	9140-0674	1	1	COIL FXD 3.3MH X 2	28480	9140-0674
A11Q1	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A11Q2	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A11Q3	1854-0477	7		TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW	04713	2N2222A
A11Q4	1853-0281	9		TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW	04713	2N2907A
A11Q5	1854-0232	2	1	TRANSISTOR NPN SI TO-39 PD=1W FT=15MHZ	28480	1854-0232
A11Q6	1854-0624	6	2	TRANSISTOR NPN 2N6308 SI TO-3 PD=125W	04713	2N6308
A11Q7	1854-0624	6		TRANSISTOR NPN 2N6308 SI TO-3 PD=125W	04713	2N6308
A11R1	0698-3452	1	1	RESISTOR 147K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1473-F
A11R2	0683-2225	3		RESISTOR 2.2K 5% .25W FC TC=-400/+700	01121	CB2225
A11R3	2100-3210	6		RESISTOR-TRMR 10K 10% C TOP-ADJ 1-TRN	28480	2100-3210
A11R4	0683-2725	8		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A11R5	0683-2725	8		RESISTOR 2.7K 5% .25W FC TC=-400/+700	01121	CB2725
A11R7	0757-0442	9		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A11R8	0757-0317			RESISTOR 1.33K 1% .125W F TC=0+-100		
A11R9	0698-4539	7	2	RESISTOR 402K 1% .125W F TC=0+-100	28480	0698-4539
A11R10	0698-4539	7		RESISTOR 402K 1% .125W F TC=0+-100	28480	0698-4539
A11R11	0761-0083	3	2	RESISTOR 68K 5% 1W MO TC=0+-200	28480	0761-0083

See introduction to this section for ordering information
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Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A11R12	0761-0083	3		RESISTOR 68K 5% 1W MO TC=0+-200	28480	0761-0083
A11R13	0811-3621	4	2	RESISTOR 8 5% 2W PW TC=0+-400		
A11R15	0683-1235	3	1	RESISTOR 12K 5% .25W FC TC=-400/+800	01121	CB1235
A11R16	0683-1805	3	1	RESISTOR 18 5% .25W FC TC=-400/+500	01121	CB1805
A11R17	2100-3211	7	1	RESISTOR-TRMR 1K 10% C TOP-ADJ 1-TRN	28480	2100-3211
A11R18	0812-0021	8	1	RESISTOR .47 5% 3W PW TC=0+-90	91637	CW2B1-3-T2-47/100-J
A11R19	0764-0015	7	1	RESISTOR 560 5% 2W MO TC=0+-200	28480	0764-0015
A11R20	0683-0335	2		RESISTOR 3.3 5% .25W FC TC=-400/+500	01121	CB33G5
A11R21	0683-1005	5		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A11R22	0683-0335	2		RESISTOR 3.3 5% .25W FC TC=-400/+500	01121	CB33G5
A11R23	0683-1005	5		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A11R24	0698-4444	3		RESISTOR 4.87K 1% .125W F TC=0+-100	24546	C4-1/8-T0-4871-F
A11R25	0683-1015	7		RESISTOR 100 5% .25W FC TC=-400/+500	01121	CB1015
A11R26	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A11R27	0683-1205	7	1	RESISTOR 12 5% .25W FC TC=-400/+500	01121	CB1205
A11R28	0683-1045			RESISTOR 100K 5%		
A11R29	0683-1045			RESISTOR 100K 5%		
A11RV1	0837-0106	2	2	VARISTOR	28480	0837-0106
A11RV2	0837-0106	2		VARISTOR	28480	0837-0106
A11T1	9140-0710	9	1	TRANSFORMER-POWER	28480	PPNR72943
A11T2	9140-0711	0	2	TRANSFORMER-DRIVE	28480	PPNR72944
A11T3	9140-0711	0		TRANSFORMER-DRIVE	28480	PPNR72944
A11U1	1826-0138	8	1	IC COMPARATOR GP QUAD 14-DIP-P PKG	01295	LM339N
A11U2	1826-0910	4	1	IC-LINEAR	28480	1826-0910
A11U3	1826-0099	0	1	IC V RGLTR TO-220	07263	7812UC
A11U4	1813-0255	3	1	IC SW-M CKT 22 PKG	28480	1813-0255
	0340-0039	7	4	TERMINAL BUSHING - TEFLON; MOUNTS IN	28480	0340-0039
	0340-0092	2		TERMINAL-STUD SPCL-FDTHRU PRESS-MTG	28480	0340-0092
	0340-0220	8	5	BEADS	28480	0340-0220
	1205-0310	7	2	HEAT SINK	28480	1205-0310
	1205-0373	2	1	HEAT SINK	28480	1205-0373
	2110-0269			FUSEHOLDER-CLIP TYPE.250-FUSE		
	1400-0249	0	11	CABLE TIE .062-.625-DIA .091-WD NYL	06383	PLT1M-8
	2360-0115	4	11	SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2360-0119	8	1	SCREW-MACH 6-32 .438-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2360-0121	2	4	SCREW-MACH 6-32 .5-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	2420-0006	0	2	NUT-HEX-W/LKWR 6-32-THD .109-IN-THK	00000	ORDER BY DESCRIPTION
	3050-0010	2	1	WASHER-FL MTLC NO. 6 .147-IN-ID	28480	3050-0010
	04145-00611	7	1	SHIELD-COVER(PATTERN SIDE)	28480	04145-00611
	04192-01208	7	1	HEAT SINK	28480	04192-01208
	04145-00612	8	1	SHIELD-COVER(COMPONENT SIDE)	28480	04145-00612
A12	04145-66512	5	1	DC POWER SUPPLY BOARD ASS'Y	28480	04145-66512
A12C1	0180-2980	1	9	CAPACITOR-FXD 1000UF+-20% 35VDC AL	28480	0180-2980
A12C2	0180-2980	1		CAPACITOR-FXD 1000UF+-20% 35VDC AL	28480	0180-2980
A12C3	0180-3184	9		CAPACITOR-FXD 2200 UF 35VDC	28480	0180-3184
A12C4	0180-3184	9		CAPACITOR-FXD 2200 UF 35VDC	28480	0180-3184
A12C5	0180-2980	1		CAPACITOR-FXD 1000UF+-20% 35VDC AL	28480	0180-2980
A12C6	0180-2980	1		CAPACITOR-FXD 1000UF+-20% 35VDC AL	28480	0180-2980
A12C7	0180-2980	1		CAPACITOR-FXD 1000UF+-20% 35VDC AL	28480	0180-2980
A12C8	0180-2980	1		CAPACITOR-FXD 1000UF+-20% 35VDC AL	28480	0180-2980
A12C9	0180-1746	5		CAPACITOR-FXD 15UF+-10% 20VDC TA	56289	150D156X9020B2
A12C10	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A12C11	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A12C12	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A12C13	0180-0116	1	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A12C14	0180-0291	3	13	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A12C15	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A12CR1	1902-0041	4	1	DIODE-ZNR 5.11V 5% DO-35 PD=.4W	28480	1902-0041
A12CR2	1902-1232	7	1	DIODE-ZNR 1N3997RA 5.6V 5% DO-4 PD=10W	04713	1N3997RA
A12CR3	1906-0053	6	1	DIODE-FW BRDG 100V 5A	28480	1906-0053
A12CR4	1901-0765	7	2	DIODE-PWR RECT 1N5812 50V 20A 35NS DO-4	12969	1N5812
A12CR5	1901-0765	7		DIODE-PWR RECT 1N5812 50V 20A 35NS DO-4	12969	1N5812
A12CR6	1901-0674	7	2	DIODE-PWR RECT 100V 3A 150NS	14099	3SF1
A12CR7	1901-0674	7		DIODE-PWR RECT 100V 3A 150NS	14099	3SF1
A12J1	1251-7463	7		CONNECTOR-12 PIN MALE	28480	1251-7463
A12J2	1251-4617	7	1	CONNECTOR 4-PIN M UTILITY	28480	1251-4617
A12J3	1251-7406	8		CONNECTOR-10 PIN MALE	28480	1251-7406
A12J4	1200-0485	2	1	SOCKET-IC 14-CONT DIP DIP-SLDR	28480	1200-0485
A12J5	1251-3283	1	1	CONNECTOR 24-PIN F MICRORIBBON	28480	1251-3283
A12J6	1251-7463	7		CONNECTOR-12 PIN MALE	28480	1251-7463
A12J7	1251-7406	8		CONNECTOR-10 PIN MALE	28480	1251-7406
A12L1	9100-3139	5		INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A12L2	9100-3139	5		INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A12L3	9100-3139	5		INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A12L4	9100-3139	5		INDUCTOR 75UH 15% .5DX.875LG	28480	9100-3139
A12L5	9140-0672	9	1	COIL- 2.2MH	28480	9140-0672

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A12L6	9140-0702	4	1	COIL- 2MH X 2	28480	PPNR72930
A12L7	9140-0675	2	1	COIL- 150UH	28480	9140-0675
A12L8	9140-0673	0	1	COIL- 1MH	28480	9140-0673
A12R1	0698-3404	3	1	RESISTOR 383 1% .5W F TC=0+-100	28480	0698-3404
A12R2	0757-0816	1	2	RESISTOR 681 1% .5W F TC=0+-100	28480	0757-0816
A12R3	0757-0816	1		RESISTOR 681 1% .5W F TC=0+-100	28480	0757-0816
A12R4	0698-0090	7	2	RESISTOR 464 1% .5W F TC=0+-100	28480	0698-0090
A12R5	0698-0090	7		RESISTOR 464 1% .5W F TC=0+-100	28480	0698-0090
A12R6	0683-5635	5		RESISTOR 56K 5% .25W FC TC=-400/+800	01121	CB5635
A12R7	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A12R8	0683-4735	4		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB4735
A12S1	3101-1973	7		SWITCH-SL 7-1A DIP-SLIDE-ASSY .1A 50VDC	28480	3101-1973
A12U1	1820-1994	4	1	IC DRVR TTL LS LINE DRVR OCTL	01295	SN74LS243N
A12U2	1820-1201	6		IC GATE TTL LS AND QUAD 2-INP	01295	SN74LS08N
A12U3	1820-1437	0		IC MV TTL LS MONOSTBL DUAL	01295	SN74LS221N
A12U4	1826-0904	6	1	IC-LINEAR	28480	1826-0904
A12W1	04145-61621	7	1	CABLE ASSEMBLY	28480	04145-61621
	0360-1901	6	2	CABLE TRANSITION	28480	0360-1901
	0361-0079	9	2	RIVET-SEMITUBULAR	28480	0361-0079
	8150-0038	1		WIRE- 22 Y	28480	8150-0038
	04145-61607	9	1	WIRING ASSEMBLY	28480	04145-61607
	04192-01207	6	1	HEAT SINK	28480	04192-01207
	2740-0003	5	2	NUT-HEX-W/LKWR 10-32-THD .125-IN-THK	00000	ORDER BY DESCRIPTION
	1251-3283		1	CONNECTOR-24 PIN		
	0380-0644		2	STUD-MOUNTING		
	2140-0577		2	WASHER		
A13	04145-66513	6	1	SMU POWER SOURCE BOARD ASS'Y	28480	04145-66513
A13C1	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A13C2	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A13C3	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A13C4	0180-3185	0	4	CAPACITOR-FXD 100UF 35 VDC AL	28480	0180-3185
A13C5	0180-3185	0		CAPACITOR-FXD 100UF 35 VDC AL	28480	0180-3185
A13C101	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A13C102	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A13C103	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A13C104	0180-3185	0		CAPACITOR-FXD 100UF 35 VDC AL	28480	0180-3185
A13C105	0180-3185	0		CAPACITOR-FXD 100UF 35 VDC AL	28480	0180-3185
A13CR1	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR2	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR3	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR4	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR5	1906-0076	3	4	DIODE-FW BRDG 400V 1A	28480	1906-0076
A13CR101	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR102	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR103	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR104	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A13CR105	1906-0076	3		DIODE-FW BRDG 400V 1A	28480	1906-0076
A13J1	1251-7406	8		CONNECTOR-10 PIN MALE	28480	1251-7406
A13J2	1251-7406	8		CONNECTOR-10 PIN MALE	28480	1251-7406
A13L1	9140-0704	6	2	COIL-5 MH X 2	28480	PPNR72932
A13L101	9140-0704	6		COIL-5 MH X 2	28480	PPNR72932
A13Q1	1854-0918	1	2	TRANSISTOR NPN TO-220AB PD=1.5W	28480	1854-0918
A13Q2	1853-0514	1	2	TRANSISTOR PNP TO-220AB PD=1.5W	28480	1853-0514
A13Q3	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A13Q4	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A13Q5	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A13Q6	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A13Q7	1854-0523	4	6	TRANSISTOR NPN SI TO-39 PD=1W FT=150MHZ	28480	1854-0523
A13Q8	1853-0232	0	6	TRANSISTOR PNP SI TO-39 PD=1W FT=200MHZ	28480	1853-0232
A13Q9	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A13Q10	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A13Q11	1854-0523			TRANSISTOR NPN SI TO-39 PD=1W FT=150MHZ	28480	1854-0523
A13Q12	1853-0232	4		TRANSISTOR PNP SI TO-39 PD=1W FT=200MHZ	28480	1853-0232
A13Q101	1854-0918	0		TRANSISTOR NPN TO-220AB PD=1.5W	28480	1854-0918
A13Q102	1853-0514	1		TRANSISTOR PNP TO-220AB PD=1.5W	28480	1853-0514
A13Q103	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A13Q104	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A13Q105	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810
A13Q106	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A13Q107	1854-0523	4		TRANSISTOR NPN SI TO-39 PD=1W FT=150MHZ	28480	1854-0523
A13Q108	1853-0232	0		TRANSISTOR PNP SI TO-39 PD=1W FT=200MHZ	28480	1853-0232
A13Q109	1854-0810	2		TRANSISTOR NPN SI PD=625MW FT=200MHZ	28480	1854-0810

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A13Q110	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A13Q111	1854-0523	4		TRANSISTOR NPN SI TO-39 PD=1W FT=150MHZ	28480	1854-0523
A13Q112	1853-0232	0		TRANSISTOR PNP SI TO-39 PD=1W FT=200MHZ	28480	1853-0232
A13R1	0683-0475	2		RESISTOR 4.7 5% .25W FC TC=-400/+500	01121	CB33G5
A13R2	0757-0424	7	4	RESISTOR 1.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1101-F
A13R3	0757-0273	4	4	RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A13R4	0757-0273	4		RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A13R5	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1101-F
A13R6	0683-0475	2		RESISTOR 4.7 5% .25W FC TC=-400/+500	01121	CB33G5
A13R7	0683-4735	5		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB5635
A13R8	0683-0825	5	4	RESISTOR 8.2 5% .25W FC TC=-400/+500	01121	CB82G5
A13R9	0683-0825	5		RESISTOR 8.2 5% .25W FC TC=-400/+500	01121	CB82G5
A13R10	0683-4735	5		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB5635
A13R11	0683-2735	8		RESISTOR 27K 5% .25W FC TC=-400/+800	01121	CB3335
A13R12	0683-2205	0	4	RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB1505
A13R13	0683-2205	0		RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB1505
A13R14	0683-2735	8		RESISTOR 27K 5% .25W FC TC=-400/+800	01121	CB3335
A13R15	0683-6825	7		RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A13R16	0698-4425	0	2	RESISTOR 1.54K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1541-F
A13R17	0757-0403	2	3	RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R-F
A13R101	0683-0475	2		RESISTOR 4.7 5% .25W FC TC=-400/+500	01121	CB33G5
A13R102	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1101-F
A13R103	0757-0273	4		RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011 F
A13R104	0757-0273	4		RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A13R105	0757-0424	7		RESISTOR 1.1K 1% .125W F TC=0+-100	24546	C4 1/8-T0-1101-F
A13R106	0683-0475	2		RESISTOR 4.7 5% .25W FC TC=-400/+500	01121	CB33G5
A13R107	0683-4735	5		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB5635
A13R108	0683-0825	5		RESISTOR 8.2 5% .25W FC TC=-400/+500	01121	CB82G5
A13R109	0683-0825	5		RESISTOR 8.2 5% .25W FC TC=-400/+500	01121	CB82G5
A13R110	0683-4735	5		RESISTOR 47K 5% .25W FC TC=-400/+800	01121	CB5635
A13R111	0683-2735	8		RESISTOR 27K 5% .25W FC TC=-400/+800	01121	CB3335
A13R112	0683-2205	0		RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB1505
A13R113	0683-2205	0		RESISTOR 22 5% .25W FC TC=-400/+500	01121	CB1505
A13R114	0683-2735	8		RESISTOR 27K 5% .25W FC TC=-400/+800	01121	CB3335
A13R115	0683-6825	7		RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A13R116	0698-4425	0		RESISTOR 1.54K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1541-F
A13R117	0757-0403	2		RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R F
A13T1	9140-0708	7	2	TRANSFORMER-FLOATING	28480	PPNR72941
A13T101	9140-0708	7		TRANSFORMER-FLOATING	28480	PPNR72941
A13U1	1826-0353	0	2	IC 7815 V RGLTR TO-220	04713	MC7815CP
A13U2	1826-0527	7		IC 337 V RGLTR TO-220	27014	LM337T
A13U101	1826-0353	0		IC 7815 V RGLTR TO-220	04713	MC7815CP
A13U102	1826-0527	7		IC 337 V RGLTR TO-220	27014	LM337T
	04145-00624		4	PLATE		
	04145-01210		4	ANGLE		
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
A15	04145-66515	8	1	FLOATING POWER SUPPLY BOARD ASS'Y	28480	04145-66515
A15C1	0180-3186	1	4	CAPACITOR-FXD 100UF 100VDC AL	28480	0180-3186
A15C2	0180-3186	1		CAPACITOR-FXD 100UF 100VDC AL	28480	0180-3186
A15C3	0180-3187	2	2	CAPACITOR-FXD 220UF 100VDC AL	28480	0180-3187
A15C4	0180-3186	1		CAPACITOR-FXD 100UF 100VDC AL	28480	0180-3186
A15C5	0180-3186	1		CAPACITOR-FXD 100UF 100VDC AL	28480	0180-3186
A15C6	0180-3187	2		CAPACITOR-FXD 220UF 100VDC AL	28480	0180-3187
A15C7	0180-2980	1		CAPACITOR-FXD 1000UF 35VDCV	28480	0180-2980
A15C8	0180-2980	1		CAPACITOR-FXD 1000UF 35VDCV	28480	0180-2980
A15C9	0180-2980	1		CAPACITOR-FXD 1000UF 35VDCV	28480	0180-2980
A15C10	0160-4832	4		CAPACITOR-FXD .01UF +-10% 100VDC CER	28480	0160-4832
A15C11	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A15C12	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A15C13	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A15C14	0180-3169	0	6	CAPACITOR-FXD 4.70UF 250VDC AL	28480	0180-3169
A15C15	0180-3169	0		CAPACITOR-FXD 4.70UF 250VDC AL	28480	0180-3169
A15C16	0180-3169	0		CAPACITOR-FXD 4.70UF 250VDC AL	28480	0180-3169
A15C17	0180-3169	0		CAPACITOR-FXD 4.70UF 250VDC AL	28480	0180-3169
A15C18	0180-3169	0		CAPACITOR-FXD 4.70UF 250VDC AL	28480	0180-3169
A15C19	0180-3169	0		CAPACITOR-FXD 4.70UF 250VDC AL	28480	0180-3169
A15C20	0160-0127	2		CAPACITOR-FXD 1UF +-20% 25VDC CER	28480	0160-0127
A15C21	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A15C22	0180-0291	3		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A15CR1	1901-0945	5	4	DIODE-PWR RECT 1KV 1A DO-41	28480	1901-0945
A15CR2	1901-0945	5		DIODE-PWR RECT 1KV 1A DO-41	28480	1901-0945
A15CR3	1901-0945	5		DIODE-PWR RECT 1KV 1A DO-41	28480	1901-0945
A15CR4	1901-0945	5		DIODE-PWR RECT 1KV 1A DO-41	28480	1901-0945
A15CR5	1906-0076	3		DIODE-FW BRDG 400V 1A	28480	1906-0076

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A15CR6	1906-0076	3		DIODE-FW BRDG 400V 1A	28480	1906-0076
A15CR7	1901-1086	7	2	DIODE-PWR RECT 50V 5A 200NS	04713	MR820
A15CR7	1906-0051	4		DIODE-FW BRDG 100V 1A	28480	1906-0051
A15CR8	1901-1086	7		DIODE-PWR RECT 50V 5A 200NS	04713	MR820
A15CR10	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A15CR11	1902-3199	9	2	DIODE-ZNR 14V 2% DO-35 PD=.4W TC=+.056%	28480	1902-3199
A15CR12	1902-3199	9		DIODE-ZNR 14V 2% DO-35 PD=.4W TC=+.056%	28480	1902-3199
A15CR14	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A15L1	9140-0705	7	1	COIL-50MH X 2	28480	PPNR72933
A15L2	9140-0706	8	1	COIL-20MH X 2	28480	PPNR72934
A15L3	9140-0707	9	1	COIL-10MH X 2	28480	PPNR72935
A15L4	9100-0541	7	6	INDUCTOR RF-CH-MLD 250UH 10% .25DX.5LG	28480	9100-0541
A15L5	9100-0541	7		INDUCTOR RF-CH-MLD 250UH 10% .25DX.5LG	28480	9100-0541
A15L6	9100-0541	7		INDUCTOR RF-CH-MLD 250UH 10% .25DX.5LG	28480	9100-0541
A15L7	9100-0541	7		INDUCTOR RF-CH-MLD 250UH 10% .25DX.5LG	28480	9100-0541
A15L8	9100-0541	7		INDUCTOR RF-CH-MLD 250UH 10% .25DX.5LG	28480	9100-0541
A15L9	9100-0541	7		INDUCTOR RF-CH-MLD 250UH 10% .25DX.5LG	28480	9100-0541
A15L10	9140-0703	5	1	COIL- 4MH X 2	28480	PPNR72931
A15L11	9140-0671	8	1	COIL-470MH	28480	9140-0671
A15R1	0811-1670	3	1	RESISTOR 2.2 5% 2W PW TC=0+-400	75042	BWH2-2R2-J
A15R2	0698-3423	6	2	RESISTOR 46.4K 1% .5W F TC=0+-100	28480	0698-3423
A15R3	0698-3423	6		RESISTOR 46.4K 1% .5W F TC=0+-100	28480	0698-3423
A15R4	0757-0839	8	2	RESISTOR 10K 1% .5W F TC=0+-100	28480	0757-0839
A15R5	0757-0839	8		RESISTOR 10K 1% .5W F TC=0+-100	28480	0757-0839
A15R6	0757-0834	3	2	RESISTOR 5.62K 1% .5W F TC=0+-100	28480	0757-0834
A15R7	0757-0834	3		RESISTOR 5.62K 1% .5W F TC=0+-100	28480	0757-0834
A15R8	0698-3439	4	2	RESISTOR 178 1% .125W F TC=0+-100	24546	C4-1/8-T0-178R-F
A15R9	0698-3439	4		RESISTOR 178 1% .125W F TC=0+-100	24546	C4-1/8-T0-178R-F
A15R10	0683-1005	5		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A15R11	0698-3446	3	1	RESISTOR 383 1% .125W F TC=0+-100	24546	C4-1/8-T0-383R-F
A15R12	0757-0440	7	1	RESISTOR 7.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7501-F
A15R13	0757-0403	2		RESISTOR 121 1% .125W F TC=0+-100	24546	C4-1/8-T0-121R-F
A15T1	9140-0709	8	1	TRANSFORMER-POWER	28480	PPNR72942
A15U1	1826-0539	7	1	IC LM317H TO-220	27014	LM317T
A15U2	1826-0558	9		IC-REG 337HLTR TO-220	27014	LM337T
A15U3	1826-0724	8	1	IC-LM350K	28480	1826-0724
A15W1	04145-61605	7	1	CABLE ASSEMBLY	28480	04145-61605
	1205-0310		1	HEAT SINK SGL TO-3-36		
	2360-0115	4		SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	00000	ORDER BY DESCRIPTION
	1250-0475		2	HEAT SINK		
A16	04145-66516	9	1	VS/VM BOARD ASS'Y	28480	04145-66516
A16C1	0160-4789	0	2	CAPACITOR-FXD 15PF +-5% 100VDC CER 0+-30	28480	0160-4789
A16C3	0160-4811	9	2	CAPACITOR-FXD 270PF	28480	0160-4811
A16C4	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C5	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C6	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C7	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C8	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C9	0160-4801	7	2	CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A16C10	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A16C11	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C12	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A16C13	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C14	0180-1083	3		CAPACITOR-FXD 33UF 25VDC AL	28480	0180-1083
A16C15	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C101	0160-4789	0		CAPACITOR-FXD 15PF +-5% 100VDC CER 0+-30	28480	0160-4789
A16C103	0160-4811	9		CAPACITOR-FXD 270PF	28480	0160-4811
A16C104	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C105	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C106	0160-4835	7		CAPACITOR-FXD .1UF +-10% 50VDC CER	28480	0160-4835
A16C109	0160-4801	7		CAPACITOR-FXD 100PF +-5% 100VDC CER	28480	0160-4801
A16CR1	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A16CR2	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR3	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR4	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR5	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR6	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR7	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR8	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR9	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR10	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A16CR11	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A16CR101	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A16CR102	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR103	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR104	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR105	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR106	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR107	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR108	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR109	1901-0033	2		DIODE-GEN PRP 180V 200MA DO-7	28480	1901-0033
A16CR110	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A16CR111	1901-0025	2		DIODE-GEN PRP 100V 200MA DO-7	28480	1901-0025
A16K1	0490-1137	5		RELAY-REED 1A	28480	0490-1137
A16K101	0490-1137	5		RELAY-REED 1A	28480	0490-1137
A16L1	9140-0137	1	5	INDUCTOR RF-CH-MLD 1MH 5% .2DX.45LG Q=60	28480	9140-0137
A16L2	9140-0137	1		INDUCTOR RF-CH-MLD 1MH 5% .2DX.45LG Q=60	28480	9140-0137
A16L3	9140-0137	1		INDUCTOR RF-CH-MLD 1MH 5% .2DX.45LG Q=60	28480	9140-0137
A16L4	9140-0137	1		INDUCTOR RF-CH-MLD 1MH 5% .2DX.45LG Q=60	28480	9140-0137
A16L5	9140-0137	1		INDUCTOR RF-CH-MLD 1MH 5% .2DX.45LG Q=60	28480	9140-0137
A16Q1	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A16Q2	1853-0264	8	2	TRANSISTOR PNP SI PD=310MW FT=100MHZ	04713	2N5401
A16Q3	1854-0474	4		TRANSISTOR NPN SI PD=310MW FT=100MHZ	04713	2N5551
A16Q4	1854-0523	4		TRANSISTOR NPN SI TO-39 PD=1W FT=150MHZ	28480	1854-0523
A16Q5	1853-0232	0		TRANSISTOR PNP SI TO-39 PD=1W FT=200MHZ	28480	1853-0232
A16Q101	1853-0459	3		TRANSISTOR PNP SI PD=625MW FT=200MHZ	28480	1853-0459
A16Q102	1853-0264	8		TRANSISTOR PNP SI PD=310MW FT=100MHZ	04713	2N5401
A16Q103	1854-0474	4		TRANSISTOR NPN SI PD=310MW FT=100MH	04713	2N5551
A16Q104	1854-0523	0		TRANSISTOR NPN SI TO-39 PD=1W FT=150MHZ	28480	1854-0523
A16Q105	1853-0232	4		TRANSISTOR PNP SI TO-39 PD=1W FT=200MHZ	28480	1853-0232
A16R1	0699-0738	2	2	RESISTOR 990K .1% .25W F TC=0+-25	28480	0699-0738
A16R2	0698-8954	8	2	RESISTOR 500K .1% .125W F TC=0+-10	28480	0698-8954
A16R3	0699-0917	9	2	RESISTOR-FXD 4.5 MEGOHM	28480	0699-0917
A16R5	0698-3495	2	2	RESISTOR 866 1% .125W F TC=0+-100	24546	C4-1/8-T0-866R-F
A16R6	0698-3152	8	2	RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A16R7	0698-5450	3	2	RESISTOR 50K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-5002-B
A16R8	0698-6358	2	2	RESISTOR 100K .1% .125W F TC=0+-25	28480	0698-6358
A16R9	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A16R10	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A16R11	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A16R12	0683-1225	1		RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A16R13	0683-1225	1		RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A16R14	0683-6825	7		RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A16R15	0683-6825	7		RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A16R16	0683-1515	2		RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A16R17	0757-0821	8	4	RESISTOR 1.21K 1% .5W F TC=0+-100	28480	0757-0821
A16R18	0757-0821	8		RESISTOR 1.21K 1% .5W F TC=0+-100	28480	0757-0821
A16R19	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A16R20	0698-8833	2	2	RESISTOR 10K .1% .125W F TC=0+-10	28480	0698-8833
A16R21	2100-3273	1	2	RESISTOR-TRMR 2K 10% C SIDE-ADJ 1-TRN	28480	2100-3273
A16R101	0699-0738	2		RESISTOR 990K .1% .25W F TC=0+-25	28480	0699-0738
A16R102	0698-8954	8		RESISTOR 500K .1% .125W F TC=0+-10	28480	0698-8954
A16R103	0699-0917	9		RESISTOR-FXD 4.5 MEGOHM	28480	0699-0917
A16R105	0698-3495	2		RESISTOR 866 1% .125W F TC=0+-100	24546	C4-1/8-T0-866R-F
A16R106	0698-3152	8		RESISTOR 3.48K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3481-F
A16R107	0698-5450	3		RESISTOR 50K .1% .125W F TC=0+-50	19701	MF4C1/8-T2-5002-B
A16R108	0698-6358	2		RESISTOR 100K .1% .125W F TC=0+-25	28480	0698-6358
A16R109	0683-1025	9		RESISTOR 1K 5% .25W FC TC=-400/+600	01121	CB1025
A16R110	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A16R111	0683-1035	1		RESISTOR 10K 5% .25W FC TC=-400/+700	01121	CB1035
A16R112	0683-1225	1		RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A16R113	0683-1225	1		RESISTOR 1.2K 5% .25W FC TC=-400/+700	01121	CB1225
A16R114	0683-6825	7		RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A16R115	0683-6825	7		RESISTOR 6.8K 5% .25W FC TC=-400/+700	01121	CB6825
A16R116	0683-1515	2		RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A16R117	0757-0821	8		RESISTOR 1.21K 1% .5W F TC=0+-100	28480	0757-0821
A16R118	0757-0821	8		RESISTOR 1.21K 1% .5W F TC=0+-100	28480	0757-0821
A16R120	0698-8833	2		RESISTOR 10K .1% .125W F TC=0+-10	28480	0698-8833
A16R121	2100-3273	1		RESISTOR-TRMR 2K 10% C SIDE-ADJ 1-TRN	28480	2100-3273
A16U1	1826-0909	1	4	IC-LINEAR LM11CH	27014	LM11CH
A16U2	1826-0909	1		IC-LINEAR LM11CH	27014	LM11CH
A16U3	1826-0909	1		IC-LINEAR LM11CH	27014	LM11CH
A16U4	1826-0909	1		IC-LINEAR LM11CH	27014	LM11CH

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
A17	04145-66517	0	1	MOTHER BOARD ASS'Y (FRONT)	28480	04145-66517
A17J1	1251-7463	7		CONNECTOR-12 PIN MALE	28480	1251-7463
A17W1	8120-3470	8	3	CABLE,MULTI-CONDUCTOR	28480	8120-3470
A17W2	8120-3470	8		CABLE,MULTI-CONDUCTOR	28480	8120-3470
A17W3	8120-3470	8		CABLE,MULTI-CONDUCTOR	28480	8120-3470
A17XA1L	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA1R	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA2L	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA2R	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA3L	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA3R	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA4L	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA4R	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA5L	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA5R	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA6L	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA6R	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA7L	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA7R	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA8L	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A17XA8R	1251-5564	5		CONNECTOR-PC 2 X 22 CONTACTS	28480	1251-5564
A18	04145-66518	1	1	MOTHER BOARD ASS'Y (REAR)	28480	04145-66518
A18C1	1810-0585	6		CAPACITOR-FXD 470PF X 8	28480	1810-0585
A18J1	1251-7406	8		CONNECTOR-10 PIN MALE	28480	1251-7406
A18J2	1251-0292	6	1	CONNECTOR 24-PIN F MICRO RIBBON	28480	1251-0292
A18W1	8120-3526	5	1	CABLE, MULTI-CONDUCTOR	28480	8120-3526
A18W2	8120-3527	6	1	CABLE, MULTI-CONDUCTOR	28480	8120-3527
A18XA13	1251-5564	5		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-5564
A18XA14	1251-5564	5		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-5564
A18XA15	1251-5564	5		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-5564
A18XA16	1251-5564	5		CONNECTOR-PC EDGE 22-CONT/ROW 2-ROWS	28480	1251-5564
A19	04145-66519	2	1	SMU FILTER BOARD ASS'Y	28480	04145-66519
A19C1	0160-3455	5	2	CAPACITOR-FXD 470PF +-10% 1KVDC CER	28480	0160-3455
A19C2	0160-3455	5		CAPACITOR-FXD 470PF +-10% 1KVDC CER	28480	0160-3455
A19C3	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A19C4	0160-4807	3	4	CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A19C5	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A19C6	0160-4807	3		CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A19C7	0160-4807	3		CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A19C8	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
A19C9	0160-4807	3		CAPACITOR-FXD 33PF +-5% 100VDC CER 0+-30	28480	0160-4807
A19C10	0160-0161	4		CAPACITOR-FXD .01UF +-10% 200VDC POLYE	28480	0160-0161
	0340-0078	4		TERMINAL-STUD SPCL-FDTHRU PRESS-MTG	98291	011-6809 000 209
	1400-0249	0		CABLE TIE .062-.625-DIA .091-WD NYL	06383	PLT1M-8
	04145-00621	9	3	SHIELD-PLATE	28480	04145-00621
A19W1	04145-61631		2	CABLE ASS'Y		
A19W2	04145-61632		2	CABLE ASS'Y		
A19W5	04145-61601		1	CABLE ASS'Y		
A19W6	04145-61602		1	CABLE ASS'Y		
A19W7	04145-61603		1	CABLE ASS'Y		
A19W8	04145-61604		1	CABLE ASS'Y		

See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
1*	04145-04001		1	FAN COVER		
2*	04145-00204		1	REAR PANEL		
3*	3160-0391		1	FAN		
4*	2110-0569		1	NUT-FUSEHOLDER		
5*	2110-0564		1	FUSE HOLDER		
6*	04145-00101		1	CHASSIS		
7*	04145-00102		1	CHASSIS		
8	1250-0118		4	CONNECTOR-RF BNC		
8	2190-0016		4	WASHER		
8	2950-0001		4	NUT		
9	5040-4503		5	FASTNER INSULATOR		
10	04145-00205		1	REAR PANEL		
11	04145-00610		1	PLATE		
12	1251-0292		1	CONNECTOR 24-PIN FEMALE		
13	1250-0687		4	CONNECTOR-RF TRIAXIAL		
14	3101-0010		1	SWITCH (SLIDE)		
15	0515-0064		1	SCREW		
16	5020-8808		1	REAR FRAME		
17	04145-00617		1	PLATE		
18	2420-0001		2	NUT		
19	04145-00602		1	PLATE		
20	04145-00605		1	SHIELD PLATE		
21	04145-00105		1	CHASSIS		
22	04145-00604		1	SHIELD PLATE		
23	04145-00607		1	SIDE PLATE		
24	04145-00603		3	SHIELD PLATE		
25	5060-9836		1	TOP COVER		
26	04145-00616		1	PLATE		
27	2360-0333		20	SCREW		
28	5020-8838		4	STRUT		
29	04145-00103		1	CHASSIS		
30	5060-9948		2	SIDE COVER		
31	5020-8807		1	FRONT FRAME		
32	04145-00108		1	CHASSIS		
33	04145-00609		1	SHIELD PLATE		
34	04145-00620		1	PLATE		
35	04145-24009		4	WASHER		
36	2200-0165		4	SCREW		
37	04145-00201		1	FRONT PANEL (HP)		
37	04145-00202		1	FRONT PANEL (YHP)		
38	04145-01205		1	ANGLE		
39	1345A		1	DIGITAL DISPLAY		
40	0950-0863		1	FLEXIBLE-DISC DRIVE		
41	04145-01206		1	ANGLE		
42	0515-0064		4	SCREW		
43	0515-0076		4	SCREW		
44	04145-00618		2	PLATE		
45	7120-1254		1	TRADE MARK (HP)		
45	7120-0478		1	TRADE MARK (YHP)		
46	04145-24002		2	NUT		
47	2100-3972		1	RESISTOR-VARIABLE 1K		
48	2100-3971		1	RESISTOR-VARIABLE 20K		
49	04145-00106		1	CHASSIS		
50	5041-0564		1	KEY CAP		
51	04145-25003		1	ROD		
52	04145-00622		2	PLATE		
53	04145-01209		1	ANGLE		
54	5060-9848		1	BOTTOM COVER		
55	5040-7201		2	FOOT		
56	1460-1345		2	WIREFORM		
57	2360-0333		4	SCREW		
58	2510-0192		16	SCREW		
59	04145-00606		1	CENTER PLATE		
60	04145-40001		3	PLATE		
61	04145-40001		1	PLATE		
62	04145-00104		1	SHASSIS		
63	1510-0038		2	BINDING POST		
63	3050-0014		5	WASHER		
63	2190-0084		2	WASHER		
63	2950-0006		2	NUT		
64	5040-7219		2	STRAP-HANDLE-CAP (FRONT)		
65	2680-0172		4	SCREW		
66	04145-00608		1	SIDE PLATE		
67	5060-9805		2	STRAP-HANDLE		
68	5040-7220		2	STRAP-HANDLE-CAP (REAR)		

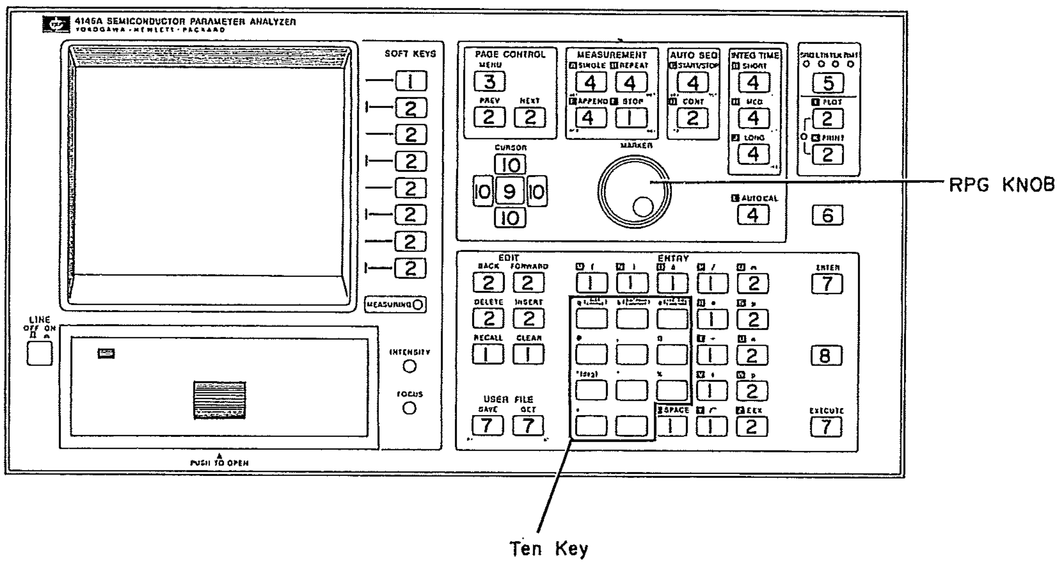
See introduction to this section for ordering information
*Indicates factory selected value

Table 6-3. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
69*	04145-61626		1	C2 (P/N 0180-3178) ASSEMBLY		
70*	2360-0115		4	SCREW		
71*	04145-61627		1	C3 (P/N 0180-3178) ASSEMBLY		
72	04192-40002		1	COUPLER		
73*	04145-00601		1	SHIELD COVER		
74*	0515-0150		2	SCREW		
75*	3101-2216		1	SWITCH		
76*	04145-01202		1	ANGLE		
77*	04145-01201		1	ANGLE		
78*	2950-0001		3	NUT		
79*	1251-4470		1	CONNECTOR-AC POWER MALE		
80*	3101-2298		2	SLIDE SWITCH		
81*	1250-0118		3	CONNECTOR-RF BNC		
82*	2110-0015		1	FUSE 2.5AT 250V		
	2110-0305		1	FUSE 2.5AT 250V		
83*	2110-0565		1	FUSE HOLDER CAP		

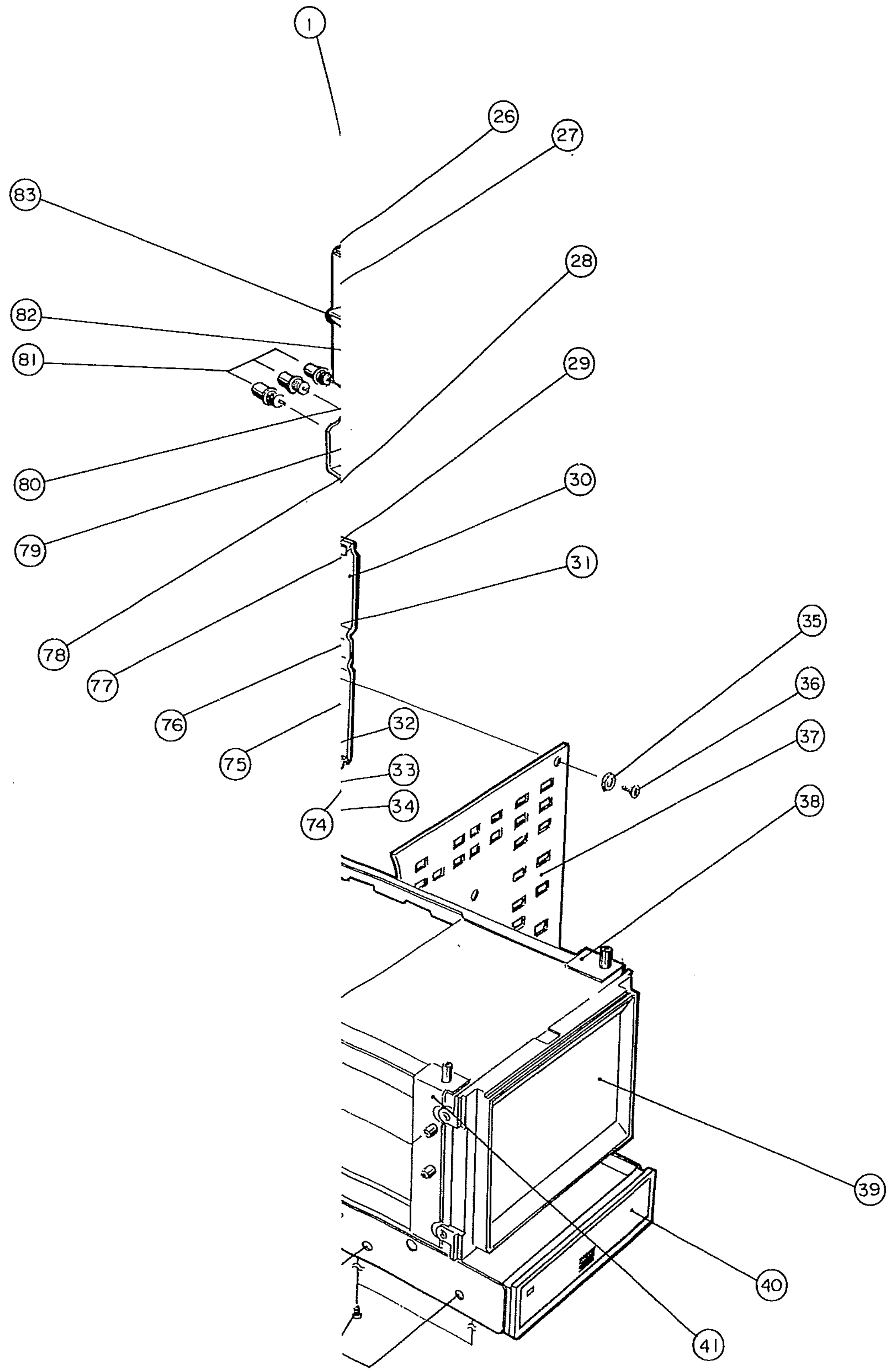
* The parts reference-numbered with * are components of the Power Supply Assembly (HP P/N: 04145-69003). The Power Supply Assembly also includes a filter (HP P/N: 9135-0084) and a transformer (HP P/N: 9100-4225), not shown in Figure 6-1.

See introduction to this section for ordering information
*Indicates factory selected value



Item	Part Number	Q'ty	Description
1	5041-0343	13	BROWN
2	5041-0277	21	PARL
3	5041-0475	1	GOLD
4	5041-0286	8	PARL
5	5041-1881	1	"LOCAL"
6	5041-0451	1	BLUE
7	5041-0376	4	BROWN
8	5041-0508	1	GREEN
9	5041-0063	1	"FAST"
10	5041-0059	4	"ARROW"
	5041-0808	1	"."
	5041-0811	1	"1"
	5041-0812	1	"2"
	5041-0813	1	"3"
Ten Key	5041-0814	1	"4"
	5041-0815	1	"5"
	5041-0816	2	"6", "9"
	5041-0817	1	"7"
	5041-0818	1	"8"
	5041-0819	1	"0"
RPG KNOB	0370-3033	1	RPG KNOB

Figure 6-2. Part Numbers for the Front Panel Key Caps.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SECTION VII
MANUAL CHANGES

7-1. INTRODUCTION

7-2. This section contains information for adapting this manual to instruments to which the contents do not directly apply. The following paragraphs explain how to adapt this manual to apply to older instruments with a lower serial prefix.

7-3. MANUAL CHANGES

7-4. To adapt this manual to your particular instrument, refer to Table 7-1 and make all of the manual changes listed opposite your instrument serial number. Perform these changes in the summary by assembly.

7-5. If your instrument serial number is not listed on the title page of this manual or in Table 7-1, it may be documented in a yellow MANUAL CHANGES supplement. For additional information about serial number coverage, refer to INSTRUMENT COVERED BY MANUAL in Section I.

Table 7-1. Manual Changes by Serial Number

Serial Prefix or Number	Make Manual Changes
2149J00115 and below	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
2149J00126 and below	2, 3, 4, 5, 6, 7, 8, 9, 10, 11
2149J00136 and below	3, 4, 5, 6, 7, 8, 9, 10, 11,
2149J00146 and below	4, 5, 6, 7, 8, 9, 10, 11
2149J00186 and below	5, 6, 7, 8, 9, 10, 11
2149J00216 and below	6, 7, 8, 9, 10, 11
2149J00241 and below	7, 8, 9, 10, 11
2149J00241 and below to 2149J00137	8, 9, 10, 11
2149J00256 and below to 2149J00137	9, 10, 11
2149J00256 and below to 2149J00242	10, 11
2149J00286 and below	11

CHANGE 1

Table 6-3, Replaceable Parts:
See Table 7-2.

CHANGE 2

Page 8-44, Figure 8-16, A3 Board Troubleshooting Flow Diagram, Sheet 2 of 9:
Change the four signature analyzer settings in Flow Diagram (A3-2) as follows:

A3W5 Setting: T Signature Analyzer Setting: START: ╲ } A3TP15 STOP: ╲ } A3TP15 CLOCK: ╲ A3TP16 WINDOW: 0003 (+5V) Turn on the 4145A.	A3W5 Setting: T Signature Analyzer Setting: START: ╲ } A3TP15 STOP: ╲ } A3TP15 CLOCK: ╲ A3U23-pin13 WINDOW: 0003 (+5V) Turn on the 4145A.
START: ╲ A3U9-pin18 STOP: ╱ A3U9-pin20 CLOCK: ╲ A3TP16 WINDOW: P254 (+5V)	START: ╲ A3U9-pin18 STOP: ╱ A3U9-pin20 CLOCK: ╲ A3U23-pin13 WINDOW: P254 (+5V)
START: ╲ A3U10-pin18 STOP: ╱ A3U10-pin20 CLOCK: ╲ A3TP16 WINDOW: P254 (+5V)	START: ╲ A3U10-pin18 STOP: ╱ A3U10-pin20 CLOCK: ╲ A3U23-pin13 WINDOW: P254 (+5V)
START: ╲ A3U11-pin18 SROP: ╱ A3U11-pin20 CLOCK: ╲ A3TP16 WINDOW: P254 (+5V)	START: ╲ A3U11-pin18 STOP: ╱ A3U11-pin20 CLOCK: ╲ A3U23-pin13 WINDOW: P254 (+5V)

Page 8-47, Figure 8-16, A3 Board Troubleshooting Flow Diagram, Sheet 5 of 9:
Change the signature analyzer setting in Flow Diagram (A3-6) as follows:

Signature Analyzer Setting:	Signature Analyzer setting:
START: ╲_ } A3TP13	START: ╲_ } A3TP13
STOP: ╲_ } A3TP13	STOP: ╲_ } A3TP13
CLOCK: ╲_ A3TP16	CLOCK: ╲_ A3U23-pin13
WINDOW: 7255 (+5V)	WINDOW: 7255 (+5V)
Turn on the 4145A.	Turn on the 4145A.

Pages 8-48 and -50, Figure 8-16, A3 Board Troubleshooting Flow Diagram, Sheets 6 and 8 of 9:
Change the signature analyzer setting in Flow Diagrams (A3-8) and (A3-11) as follows:

Signature Analyzer Setting:	Signature Analyzer Setting:
START: ╲_ } A3TP13	START: ╲_ } A3TP13
STOP: ╲_ } A3TP13	STOP: ╲_ } A3TP13
CLOCK: ╲_ A3TP15	CLOCK: ╲_ A3U23-pin13
WINDOW: PPFA (+5V)	WINDOW: PPFA (+5V)
Turn on the 4145A.	Turn on the 4145A.

Pages 8-51, Figure 8-16, A3 Board Troubleshooting Flow Diagram, Sheet 9 of 9:
Change both signature analyzer setting in Flow Diagram (A3-12) as follows:

Signature Analyzer Settings:	Signature Analyzer Settings:
START: ╲_ } A3TP13	START: ╲_ } A3TP16
STOP: ╲_ } A3TP13	STOP: ╲_ } A3TP16
CLOCK: ╲_ A3TP16	CLOCK: ╲_ A3U23-pin13
WINDOW: F8PA (+5V)	WINDOW: F8PA (+5V)

Pages 8-53 and -54, Figure 8-17, A4 Board Troubleshooting Flow Diagram, Sheets 1 and 2 of 5:

Change the signature analyzer setting in Flow Diagrams (A4-1) and (A4-2) as follows:

Signature Analyzer Setting:	
START:	A3TP13
STOP:	A3TP13
CLOCK:	A3TP15
WINDOW:	U675 (+5V)

Signature Analyzer Setting:	
START:	A3TP13
STOP:	A3TP13
CLOCK:	A3U23-pin13
WINDOW:	U675 (+5V)

CHANGE 3

Table 6-3, Replaceable Parts:
See Table 7-2.

Page 8-36, Figure 8-15, A2 Board Troubleshooting Flow Diagram, Sheet 6 of 12:
Change Table 4 and Table 5 in Flow Diagram A2-7 as follows:

Table 4

	Insert TEST ROM (A1U8) into the A2U14 socket	Insert A2U14 into the A2U14 socket
ROM P/N	04145-85018	04145-85014
Test Point	Signature	Signature
A2U4-pin 11	8A39	FAPP
pin 12	FFPA	87C4
pin 13	268A	OPU3
pin 14	PAAU	535A
pin 15	1H5A	0921
pin 16	3A70	8A28
pin 17	68UC	48A2
pin 18	2617	P121

Table 5

	Insert TEST ROM (A1U8) into the A2U14 socket	Insert A2U14 into the A2U14 socket
ROM P/N	04145-85018	04145-85014
Test Point	Signature	Signature
A2U4-pin 2	2617	P121
pin 3	68UC	48A2
pin 4	3A70	8A28
pin 5	1H5A	0921
pin 6	PAAU	535A
pin 7	268A	OPU3
pin 8	FFPA	87C4
pin 9	8A39	F4PP

Page 8-37, Figure 8-15, A2 Board Troubleshooting Flow Diagram, Sheet 7 of 12:
Change the first, second, third, fourth and fifth signature sets in Flow Diagram (A2-8) as follows:

*1

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	P0P5
pin 12	9FH5
pin 13	4HCU
pin 14	95F5
pin 15	59FA
Pin 16	9691
pin 17	A4C2
pin 18	UFF3

*1: TEST ROM (A1U8: P/N 04145-85028) must be inserted into the A2U14 socket.

⇨

*1

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	5P77
pin 12	C807
pin 13	UUP0
pin 14	HC95
pin 15	U4A4
pin 16	6H12
pin 17	FFA7
pin 18	0186

*1: TEST ROM (A1U8: P/N 04145-85018) must be inserted into the A2U14 socket.

*2

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	07HC
pin 12	27CP
pin 13	270U
pin 14	6729
pin 15	97CH
pin 16	CP3A
pin 17	6FU5
pin 18	A6U0

*2: Part number of A2U14 must be 04145-85034.

⇨

*2

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	63CH
pin 12	9360
pin 13	UPP8
pin 14	0057
pin 15	0737
pin 16	693A
pin 17	1F49
pin 18	449F

*2: Part number of A2U14 must be 04145-85014.

*3

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	9656
pin 12	68C6
pin 13	H031
pin 14	PPFA
pin 15	93C3
pin 16	458U
pin 17	F54F
pin 18	7U43

*3: Part number of A2U13 must be 04145-85023.

*3

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	27UA
pin 12	3A8F
pin 13	F598
pin 14	1720
pin 15	90AP
pin 16	F4P6
pin 17	90F8
pin 18	8CPP

*3: Part number of A2U13 must be o4145-85013.

*4

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	P460
pin 12	H812
pin 13	6FAP
pin 14	93H9
pin 15	H947
pin 16	448H
pin 17	36C2
pin 18	1P57

*4: Part number of A2U27 must be 04145-85022.

*4

Is the following signature set corrct?

Test Point	Signature
A2U4-pin 11	H0A5
pin 12	435F
pin 13	UF63
pin 14	A6F4
pin 15	P787
pin 16	1447
pin 17	47F0
pin 18	9UPC

*4: Part number of A2U27 must be 04145-85012.

*5

Test Point	Signature
A2U4-pin 11	06UA
pin 12	7H98
pin 13	P713
pin 14	6HU7
pin 15	PH6F
pin 16	18C3
pin 17	2351
pin 18	P4CA

*5: Part number of A2U26 must be 04145-85021.

*5

Test Point	Signature
A2U4-pin 11	A28F
pin 12	9819
pin 13	2537
pin 14	48C4
pin 15	6UHP
pin 16	PF20
pin 17	3UH3
pin 18	H247

*5: Part number of A2U26 must be 04145-85011.

Page 8-44, Figure 8-16, A3 Board Troubleshooting Flow Diagram, Sheet 2 of 9:
Change the signature sets for A3U10 and A3U11 given at the end of Flow Diagram (A3-2) as follows:

Test Point	Signature
A3U10-pin 9	9H34
pin 10	32A1
pin 11	4305
pin 13	9FUC
pin 14	C140
pin 15	C3P7
pin 16	5323
pin 17	6AA0

⇨

Test Point	Signature
A3U10-pin 9	3279
pin 10	4A26
pin 11	AF36
pin 13	5F5U
pin 14	FCH4
pin 15	8A8P
pin 16	6C42
pin 17	3221

Test Point	Signature
A3U11-pin 9	F25P
pin 10	241A
pin 11	8AU9
pin 13	8HOF
pin 14	0620
pin 15	HA49
pin 16	917H
pin 17	4C92

⇨

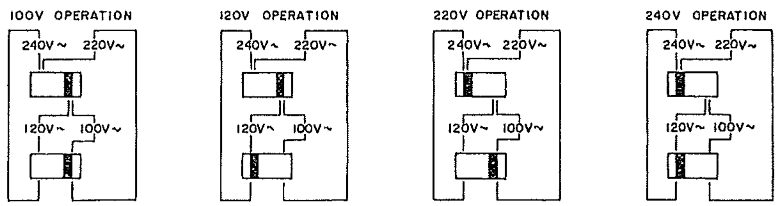
Test Point	Signature
A3U11-pin 9	A401
pin 10	H76P
pin 11	AC9F
pin 13	47AP
pin 14	U7CC
pin 15	C56F
pin 16	37H2
pin 17	172A

Change Table 2 as follows:

Part numbers of A3U9, U10 and U11		
A3U9	A3U10	A3U11
04145-85015	04145-85016	04145-85017

CHANGE 4

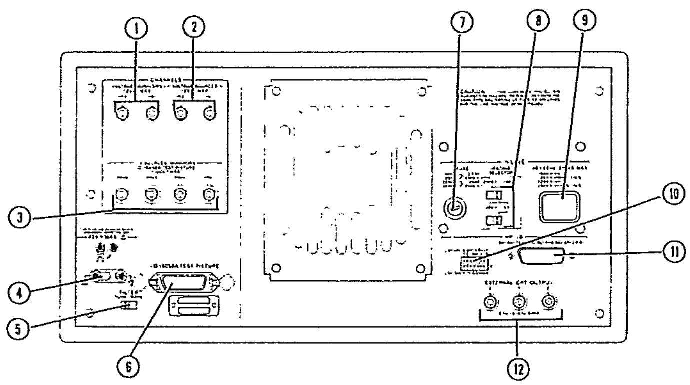
Page 2-2, Figure 2-1, Voltage and Fuse Selection:
Change the figure as shown below:



Fuse: 2.5A 250V∿
(HP P/N: 2110-0015)

Fuse: 1.25A 250V∿
(HP P/N: 2110-0305)

Page 3-8, Figure 3-3, Rear Panel Features:
Partially change the figure as shown below:



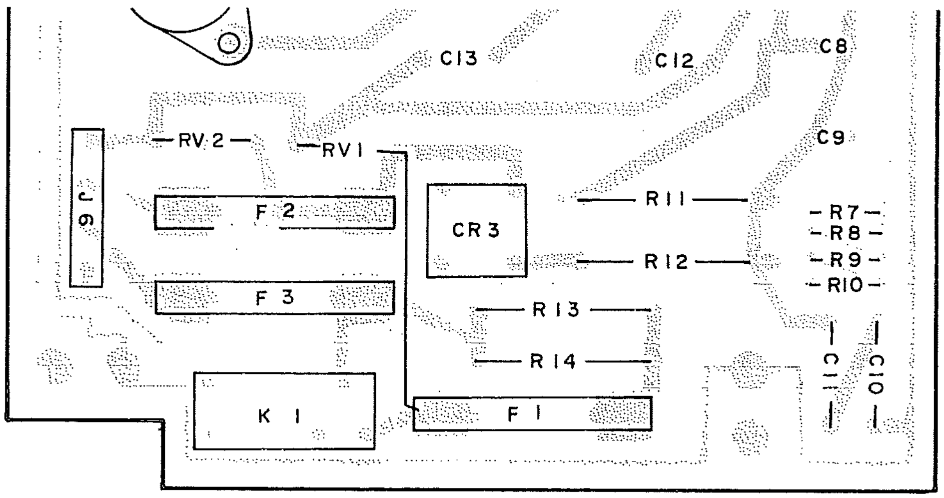
CHANGE 5

Table 6-3, Replaceable Parts:
See Table 7-2.

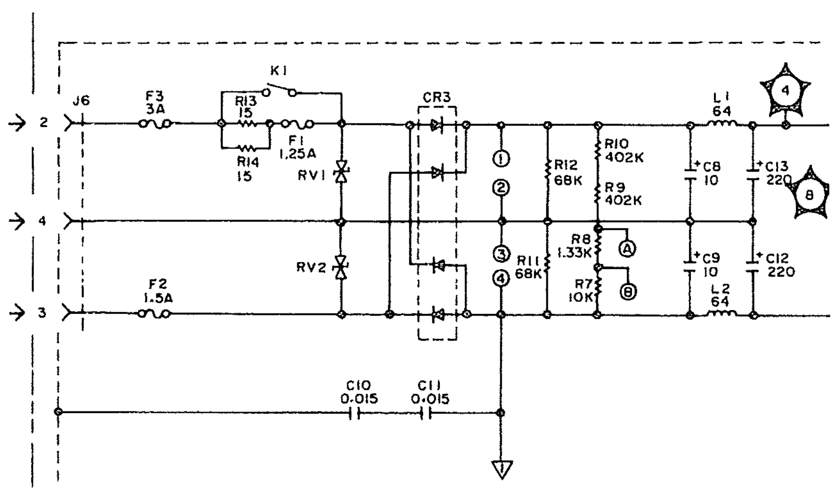
CHANGE 6

Table 6-2, Replaceable Parts:
See Table 7-2.

Page 8-122, Figure 8-58, All Board Component Locations:
Partially change the figure as shown below:



Page 8-123, Figure 8-59, All Board Schematic Diagram:
Partially change the figure as shown below:



CHANGE 7

Table 6-3, Replaceable Parts:
See Table 7-2.

Page 8-36, Figure 8-15, A2 Board Troubleshooting Flow Diagram, Sheet 6 of 12:
Change Table 4 and Table 5 as follows:

Table 4

	Insert TEST ROM (A1U8) into the A2U14 socket	Insert A2U14 into the A2U14 socket
ROM P/N	04145-85018	04145-85024
Test Point	Signature	Signature
A2U4-pin 11	8A39	F84P
pin 12	FFPA	C958
pin 13	268A	UA6A
pin 14	PAAU	PC7F
pin 15	1H5A	UA6F
pin 16	3A70	5079
pin 17	68UC	8FH4
pin 18	2617	C7UP

Table 5

	Insert TEST ROM (A1U8) into the A2U14 socket	Insert A2U14 into the A2U14 socket
ROM P/N	04145-85018	04145-85024
Test Point	Signature	Signature
A2U4-pin 2	2617	C7UP
pin 3	68UC	8FH4
pin 4	3A70	5079
pin 5	1H5A	UA6F
pin 6	PAAU	PC7F
pin 7	268A	UA6A
pin 8	FFPA	C958
pin 9	8A39	F84P

Page 8-37, Figure 8-15, A2 Board Troubleshooting Flow Diagram, Sheet 7 of 12:
Change the first, second, fourth and fifth signature sets in Flow Diagram (A2-8) as follows:

*1

Is the following signature set collect?

Test Point	Signature
A2U4-pin 11	P0P5
pin 12	9FH5
pin 13	4HCU
pin 14	95F5
pin 15	59FA
pin 16	9691
pin 17	A4C2
pin 18	UFF3

*1: TEST ROM (A1U8: P/N 04145-85028) must be inserted into the A2U14 socket.

*1

Is the following signature set collect?

Test Point	Signature
A2U4-pin 11	5P77
pin 12	C807
pin 13	UUP0
pin 14	HC95
pin 15	U4A4
pin 16	6H12
pin 17	FFA7
pin 18	0186

*1: TEST ROM (A1U8: P/N 04145-85018) must be inserted into the A2U14 socket.

*2

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	07HC
pin 12	27CP
pin 13	270U
pin 14	6729
pin 15	97CH
pin 16	CP3A
pin 17	6FU5
pin 18	A6U0

*2: Part number of A2U14 must be 04145-85034.

*2

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	A5A0
pin 12	865U
pin 13	0844
pin 14	PHF1
pin 15	370F
pin 16	6835
pin 17	FFP4
pin 18	9P5H

*2: Part number of A2U14 must be 04145-85024.

*4

Is the following signature set correct?	
Test Point	Signature
A2U4-pin 11	P460
pin 12	H812
pin 13	6FAP
pin 14	93H9
pin 15	H947
pin 16	448H
pin 17	36C2
pin 18	1P57

*4: Part number of A2U27 must be 04145-85022.

→

*4

Is the following signature set correct?	
Test Point	Signature
A2U4-pin 11	H0A5
pin 12	435F
pin 13	UF63
pin 14	A6F4
pin 15	P787
pin 16	1447
pin 17	47F0
pin 18	9UPC

*4: Part number of A2U27 must be 04145-85012.

*5

Is the following signature set correct?	
Test Point	Signature
A2U4-pin 11	06UA
pin 12	7H98
pin 13	P713
pin 14	6HU7
pin 15	PH6F
pin 16	18C3
pin 17	2351
pin 18	P4CA

*5: Part number of A2U26 must be 04145-85021.

→

*5

Is the following signature set correct?	
Test Point	Signature
A2U4-pin 11	A28F
pin 12	9819
pin 13	2537
pin 14	48C4
pin 15	6UHP
pin 16	PF20
pin 17	3UH3
pin 18	H247

*5: Part number of A2U26 must be 04145-85011.

Page 8-44, Figure 8-16, A3 Board Troubleshooting Flow Diagram, Sheet 2 of 9:
Change the signature set for A3U11 given at the end of Flow Diagram (A3-2) as follows:

Test Point	Signature
A3U11-pin 9	F25P
pin 10	241A
pin 11	8AU9
pin 13	8H0F
pin 14	0620
pin 15	HA49
pin 16	917H
pin 17	4C92

⇨

Test Point	Signature
A3U11-pin 9	A401
pin 10	H76P
pin 11	AC9F
pin 13	47AP
pin 14	U7CC
pin 15	C56F
pin 16	37H2
pin 17	172A

Change Table 2 as follows:

Part numbers of A3U9, U10 and U11		
A3U9	A3U10	A3U11
04145-85015	04145-85026	04145-85027

CHANGE 8

Pages 8-28, and 29 Figure 8-14, A1 Board Troubleshooting Flow Diagram, Sheets 4 of 5 and 5 of 5:
Change Flow Diagrams (A1-5) and (A1-6) as given in page 7-20 and 7-21.

CHANGE 9

Table 6-3, Replaceable Parts:
See Table 7-2.

CHANGE 10

Page 8-36, Figure 8-15, A2 Board Troubleshooting Flow Diagram, Sheet 6 of 12:
Change Table 4 and Table 5 as follows:

Table 4

	Insert TEST ROM (A1U8) into the A2U14 socket	Insert A2U14 into the A2U14 socket
ROM P/N	04145-85028	04145-85024
Test Point	Signature	Signature
A2U4-pin 11	1CU6	F84P
pin 12	78C7	C958
pin 13	28U7	VA6A
pin 14	7C4F	PC7F
pin 15	UUUU	UA6F
pin 16	6A4U	5079
pin 17	33U9	8FH4
pin 18	65CH	C7UP

Table 5

	Insert TEST ROM (A1U8) into the A2U14 socket	Insert A2U14 into the A2U14 socket
ROM P/N	04145-85028	04145-85024
Test Point	Signature	Signature
A2U4-pin 11	65CH	C7UP
pin 12	33U9	8FH4
pin 13	6A4U	5079
pin 14	UUUU	UA6F
pin 15	7C4F	PC7F
pin 16	28U7	UA6A
pin 17	78C7	C958
pin 18	1CU6	F84P

Page 8-37, Figure 8-15, A2 Board Troubleshooting Flow Diagram, Sheet 7 of 12:
Change the second, fourth and fifth signature sets in Flow Diagram (A2-8) as follows:

*2

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	07HC
pin 12	27CP
pin 13	270U
pin 14	6729
pin 15	97CH
pin 16	CP3A
pin 17	6FU5
pin 18	A6U0

*2: Part number of A2U14 must be 04145-85034.

*2

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	A5A0
pin 12	865U
pin 13	0844
pin 14	PHF1
pin 15	370F
pin 16	6835
pin 17	FFP4
pin 18	9P5H

*2: Part number of A2U14 must be 04145-85024.

*4

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	P460
pin 12	H812
pin 13	6FAP
pin 14	93H9
pin 15	H947
pin 16	448H
pin 17	36C2
pin 18	1P57

*4: Part number of A2U27 must be 04145-85022.

*4

Is the following signature set correct?

Test Point	Signature
A2U4-pin 11	H0A5
pin 12	435F
Pin 13	UF63
pin 14	A6F4
pin 15	P787
pin 16	1447
pin 17	47F0
pin 18	9UPC

*4: Part number of A2U27 must be 04145-85012.

*5

Is the following signature set correct?	
Test Point	Signature
A2U4-pin 11	06UA
pin 12	7H98
pin 13	P713
pin 14	6HU7
pin 15	PH6F
pin 16	18C3
pin 17	2351
pin 18	P4CA

*5: Part number of A2U26 must be 04145-85021.

→

*5

Is the following signature set correct?	
Test Point	Signature
A2U4-pin 11	A28F
pin 12	9819
pin 13	2537
pin 14	48C4
pin 15	6UHP
pin 16	PF20
pin 17	3UH3
pin 18	H247

*5: Part number of A2U26 must be 04145-85011.

Page 8-44, Figure 8-16, A3 Board Troubleshooting Flow Diagram, Sheet 2 of 9:
Change the signature set for A3U11 given at the end of Flow Diagram A3-2 as follows:

Test Point	Signature
A3U11-pin 9	F25P
pin 10	241A
pin 11	8AU9
pin 13	8H0F
pin 14	0620
pin 15	HA49
pin 16	917H
pin 17	4C92

→

Test Point	Signature
A3U11-pin 9	A401
pin 10	H76P
pin 11	AC9F
pin 13	47AP
pin 14	U7CC
pin 15	C56F
pin 16	37H2
pin 17	172A

Change Table 2 as follows:

Part numbers of A3U9, U10 and U11		
A3U9	A3U10	A3U11
04145-85015	04145-85026	04145-85027

CHANGE 11

Table 6-3, Replaceable Parts:
See Table 7-2.

Change	Page	Note	Reference Designation	HP Part Number	Description
1	6-22	C	A13R1	0683-0335	RESISTOR 3.3 5% .25W
		C	R6	0683-0335	RESISTOR 3.3 5% .25W
		C	R7	0683-5635	RESISTOR 56K 5% .25W
		C	R10	0683-5635	RESISTOR 56K 5% .25W
		C	R11	0683-3335	RESISTOR 33K 5% .25W
		C	R12	0683-1505	RESISTOR 15 5% .25W
		C	R13	0683-1505	RESISTOR 15 5% .25W
		C	R14	0683-3335	RESISTOR 33K 5% .25W
		C	R101	0683-0335	RESISTOR 3.3 5% .25W
		C	R106	0683-0335	RESISTOR 3.3 5% .25W
		C	R107	0683-5635	RESISTOR 56K 5% .25W
		C	R110	0683-5635	RESISTOR 56K 5% .25W
		C	R111	0683-3335	RESISTOR 33K 5% .25W
		C	R112	0683-1505	RESISTOR 15 5% .25W
		C	R113	0683-1505	RESISTOR 15 5% .25W
		C	R114	0683-3335	RESISTOR 33K 5% .25W
		C	U1	1826-0106	IC 7815V RGLTR TO-220
		C	U101	1826-0106	IC 7815V RGLTR TO-220
	6-23	A	A15M/P	1205-0295	HEAT SINK
3	6-5	C	A2U13	04145-85013	IC-PROM
		C	A2U14	04145-85014	IC-PROM
	6-9	C	A3U10	04145-85016	IC-PROM
		C	A3U11	04145-85017	IC-PROM
5	6-15	C	A5R60	5080-3062	RESISTIVE NETWORK
6	6-19	C	A11F1	2110-0305	FUSE 1.25AT 250V
	6-20	C	A11R13	0811-1788	RESISTOR 15 5% 2W
		A	A11R14	0811-1788	RESISTOR 15 5% 2W
		D	A11R28		
		D	A11R29		
7	6-3	C	A1U8	04145-85018	IC-PROM

Change	Page	Note	Reference Designation	HP Part Number	Description
9	6-5	C	A2U14	04145-85024	IC-PROM
	6-6	C	A2U26	04145-85011	IC-PROM
		C	A2U27	04145-85012	IC-PROM
	6-9	C	A3U11	04145-85027	IC-PROM
11	6-10	C	A4C46 thru C55	0160-4810	CAPACITOR-FXD 330pF 5% 100VDC
	6-11	C	A4R43 thru R52	0683-1035	RESISTOR 1K 5% .25W
	6-25	C	A19M/P	0340-0060	TERMINAL-STUD

Flow Diagram A1 - 5

START

Turn off the 4145A.

Jumper and switch settings:

A1W1: T
A1W2: N
A1W3: N
A1W4: N
A1W5: T
A2W3: Removed (off)
A2S1 setting:

Signature Analyzer Setting:

START: A2TP17
STOP: A2TP17
CLOCK: A2TP13
WINDOW: 527A (+5V)
Turn on the 4145A.

Is the signature at A1U34-pin 4 "5P5H". — YES / NO: Check A1U34 and A2U53.

Is the signature at A1U34-pin 10 "0F27"? — YES / NO: Replace A1U34.

1) Turn off the 4145A.
2) Change A2S1 setting as follows:
3) Turn on the 4145A.

Is the signature at A1TP17 "84H4"? — YES / NO: Check DSA setup.

Is the signature at A1U19-pin 1 "8AP2"? — YES / NO: Check A1U19 and U33.

Is the signature at A1U20-pin 1 "67CH"? — YES / NO: Check A1U20, U33, and U4.

Is the signature at A1TP7 "6FA5"? — YES → A / NO: Go to Flow Diagram A1-3.

A

Is the signature at A1TP8 "84H4"? — YES / NO: Go to Flow Diagram A1-6.

Is the signature at A1U10-pin 11 "FAC7"? — YES / NO: Check A1U10 and U3.

Is the signature at A1U10-pin 9 "A613"? — YES / NO: Check A1U10 and U3.

Is the signature at A1U24-pin 2 "67CH"? — YES / NO: Check A1U4, U12, and U11.

Is the signature at A1U4-pin 8 "67CH"? — YES / NO: Check A1U12, U11 and U24.

Is the signature at A1U24-pin 13 "84H4"? — YES / NO: Check A1U11 and U24.

Is the signature at A1TP10 "P369"? — YES / NO: Check A1U24, U5, U17, and U18.

Change Signature Analyzer Setting:
CLOCK ⟶ CLOCK

Is the following signature set correct?

Test Point	Signature
A1U5-pin 12	4C04
pin 13	84H4
pin 3	A127
pin 2	H1P7
pin 6	UF1U
pin 7	H894

YES / NO: Check A1U5 and check for a stuck node.

Is the following signature set correct?

Test Point	Signature
A1U6-pin 12	5A86
pin 13	84H4
pin 3	762U
pin 2	F105
pin 6	6125
pin 7	722P

YES → B / NO: Check A1U6 and check for a stuck node.

B

Is the following signature set correct?

Test Point	Signature
A1U7-pin 12	33H2
pin 13	84H4
pin 3	2A74
pin 2	30CP
pin 6	U5H6
pin 7	U0CH

YES / NO: Check A1U7 and check for a stuck node.

Is the following signature set correct?

Test Point	Signature
A1U13-pin 4	551U
pin 7	657C
pin 9	7AHP
pin 12	9CFP

YES / NO: Replace A1U13.

Is the following signature set correct?

Test Point	Signature
A1U14-pin 4	5249
pin 7	1A15
pin 9	11FH
pin 12	450C

YES / NO: Replace A1U14.

Is the following signature set correct?

Test Point	Signature
A1U15-pin 4	382C
pin 7	H3AA
pin 9	A391
pin 12	CCC9

YES / NO: Replace A1U15.

Change Signature Analyzer Setting:
CLOCK ⟶ CLOCK

Is the following signature set correct?

Test Point	Signature
A1U17-pin 2	F6A9
pin 19	6555
pin 5	7911
pin 16	P47P
pin 6	HU36
pin 15	1523
pin 9	F13A
pin 12	25U5

YES / NO: Check A1U17 and check for a stuck node.

Is the following signature set correct?

Test Point	Signature
A1U18-pin 2	9HU2
pin 19	6766
pin 5	0P82
pin 16	4HUU
pin 6	424P
pin 15	A3FU
pin 9	U83P

YES / NO: Check A1U18 and check for a stuck node.

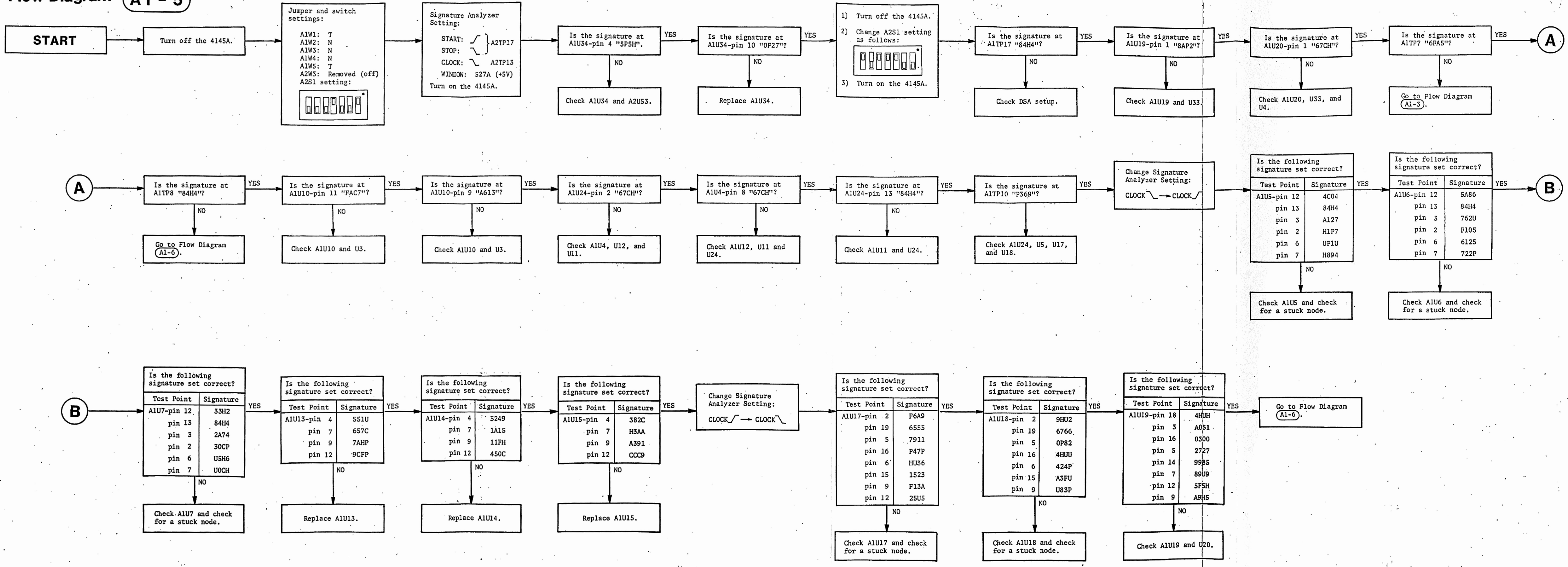
Is the following signature set correct?

Test Point	Signature
A1U19-pin 18	4HUH
pin 3	A051
pin 16	0300
pin 5	2727
pin 14	9985
pin 7	89U9
pin 12	5F5H
pin 9	A9H5

YES / NO: Check A1U19 and U20.

Go to Flow Diagram A1-6.

Flow Diagram A1 - 5



SECTION VIII
SERVICE

8-1. INTRODUCTION

8-2. This section provides information and instructions for troubleshooting and repairing the Model 4145A Semiconductor Parameter Analyzer, exclusive of the digital display. (For service information on the 1345A Digital Display, refer to the 1345A Operating and Service Manual, located at the back of this binder.) A block-diagram discussion, troubleshooting guide, and complete circuit schematics are included. Component locators are given on the page facing each board assembly schematic. An illustration of the instrument's interior is shown in Figure 8-2.

8-3. SAFETY CONSIDERATIONS

8-4. This section contains warnings and cautions that must be observed to ensure the safety of service personnel and to prevent damage to the instrument.

WARNING

MAINTENANCE DESCRIBED HEREIN IS PERFORMED WITH POWER SUPPLIED AND PROTECTIVE COVERS REMOVED. SUCH MAINTENANCE SHOULD BE PERFORMED ONLY BY SERVICE TRAINED PERSONNEL AWARE OF THE HAZARDS INVOLVED. WHERE MAINTENANCE CAN BE PERFORMED WITHOUT POWER APPLIED, THE POWER SHOULD BE REMOVED. AFTER ANY REPAIR IS COMPLETED, ENSURE THAT ALL SAFETY FEATURES ARE INTACT AND FUNCTIONING PROPERLY AND THAT ALL NECESSARY PARTS ARE CONNECTED TO THEIR MEANS OF PROTECTIVE GROUNDING.

8-5. RECOMMENDED TEST EQUIPMENT

8-6. Test equipment required for troubleshooting and repairing the 4145A is listed in Table 4-1. If the recommended model is not available, equipment which meets or exceeds the listed specifications may be used.

8-7. TROUBLESHOOTING

8-8. Before troubleshooting the 4145A, make sure that the failure is not caused by a faulty disc or a dirty read head. If the disc is damaged or worn because of prolonged use or improper handling or storage, or if the read head in the flexible-disc drive is dirty, the instrument may not be able to correctly or completely read the operating system software. Checking both of these possibilities, before troubleshooting, will effectively eliminate time wasted in tracking down a nonexistent hardware failure. If the failure is not caused by the disc or read head, refer to the troubleshooting guide given in paragraph 8-15. It provides step-by-step procedures, in flow diagram form, designed to isolate most failures to a component or circuit level.

8-9. REPAIR

8-10. Instructions for removing major assemblies are given in paragraphs 8-17 through 8-35. Take special care when removing or working near the digital display. For instructions on removal of the CRT itself, refer to the 1345A Operating and Service Manual, located at the back of this binder.

8-11. BLOCK-DIAGRAM DISCUSSION

8-12. The overall block diagram of the 4145A is shown in Figure 8-2. An explanation of the various ground references used throughout the instrument will be given first, followed by descriptions of the four major sections--measurement section, measurement control section, digital control section, and power supply section. (Refer to Figure 8-1.)

When the shorting-bar on the rear panel is connected, the digital and analog grounds (▽D and ▽) in the floating section (enclosed in dashed lines) are tied directly to chassis ground. Complete isolation between the floating and grounded sections is obtained by disconnecting the shorting bar. Regardless of whether the shorting-bar is connected or not, output from the SMUs and voltages sources is always referenced to analog ground (▽). To ensure proper ground isolation between the floating circuits and grounded circuits, optocouplers are used for data transmission between the A2 and A3 microprocessors. SMU power source commons (▽S1 , ▽S2 , ▽S3 , ▽S4) are independent of each other, and each is floating above analog ground. The level at which each SMU common is floating is primarily determined by the specified output from the corresponding SMU, and it can range from 0V to greater than ±100V. The ground reference (▽) for the switching circuits on the A11 board is floating at approximately 120 - 160Vdc below chassis ground. Functionally, the 4145A has four major circuit sections : (1) Measurement Section, (2) Measurement Control Section, (3) Digital Control Section, and (4) Power Supply Section. Each is briefly discussed below.

(1) Measurement Section :

The measurement section consists of four SMUs (A5 through A8), two voltage sources and two voltage monitors (A16), and four SMU filters (A19). Each SMU has two modes of operation : (1) V mode--voltage source/current monitor, and (2) I mode--current source/voltage monitor. In V mode, the SMU outputs up to ±100V; in I mode, up to ±100mA. The basic circuit of one SMU consists of a power amplifier, a voltage monitor, a current monitor, range resistor, and various control circuits. The power amplifier amplifies a precise reference voltage which is proportional to the specified SMU output voltage or current. The load seen by the power amplifier consists of the range resistor and DUT connected in series. The voltage monitor is connected across the DUT, and the current monitor is connected across the range resistor. In V mode operation, the voltage across the DUT is fed back to the input of the power amplifier, where it is summed with the reference voltage to control the output from the power amplifier and to keep the voltage across the DUT constant when the DUT resistance changes. Because the range resistor and DUT are connected in series, the current flowing through the DUT must also flow through the range resistor. The range resistor value is known. The current monitor measures the voltage drop across the range resistor, and the microprocessor calculates the DUT current from the known range resistor value and measured range resistor voltage using a standard Ohm's law equation. The result is sent to the A2 board for display and is also used for current compliance control. I mode operation is almost identical to V mode operation. The current through the DUT is measured by the current monitor and is fed back to the input of the power amplifier, where it is summed with the reference voltage (different from that used in V mode) to control the output from the power amplifier and to keep the current through the DUT constant when the DUT resistance changes. The voltage across the DUT is measured by the voltage monitor. The result is sent to the A2 board for display and is also used for voltage compliance control. Two reference voltages are used : one for V mode operation and one for I mode operation. Both are supplied from the D-A converter on the A4 board and are normalized at 0V to ±10V. Also, voltage and current measurement results are normalized at 0V to ±10V and then applied to the A-D converter on the A3 board before being sent to the A2 board.

The A16 board contains two voltage sources and two voltage monitors. Each voltage source is a constant gain (x2) amplifier which amplifies a reference voltage. Each has a complementary--symmetry output stage which keeps the voltage applied to the DUT constant when the DUT resistance changes. Each voltage monitor is simply an amplifier whose gain is x5 for input voltages less than ±2V, and x0.5 for input voltages higher than ±2V. Maximum allowable input is ±20V.

The A19 board contains four low-pass filters (one for each SMU) which reject normal mode noise picked up by the measurement cables.

(2) Measurement Control Section :

This section consists of the A3 and A4 boards, and it controls the SMUs, voltage sources, and voltage monitors. Basically, the A3 board contains a microprocesser, a successive-approximation A-D converter, and a ten-channel multiplexor. The A3 microprocessor directly controls the measurement circuits as directed by the host microprocessor on the A2 board. Data transmission between the A3 microprocessor and the A2 microprocessor is via optocouplers to insure proper ground isolation. The V monitor and I monitor outputs from each SMU and the outputs from the two voltage monitors on the A16 board are applied to the A3 A-D converter through the ten-channel multiplexor. The multiplexor sequentially selects one channel for A-D conversion. Only channels used in the measurement are selected for A-D conversion. For example, if SMU1 is not selected on the CHANNEL DEFINITION page (see Figure 3-21), the multiplexor will not select the SMU1 V monitor and I monitor inputs.

The A4 board contains a D-A converter, a ten-channel demultiplexor, and ten sample/hold amplifier. It provides the reference voltages used by the SMUs and voltage sources. The reference voltages, which range from 0V to ±10V with .5mV resolution, are generated by the D-A converter in response to digital data sent from the A3 microprocessor. The output from the D-A converter is applied to the demultiplexor, which distributes the reference voltage to the appropriate sample/hold amplifier.

(3) Digital Control Section :

This section consists of the A1, A2, A9, and A10 boards, the flexible-disc drive, and the 1345A Digital Display. The A2 provides overall instrument control. It contains an 8-bit microprocessor, 16K bytes of read-only memory, 32K bytes of random-access memory, and a synchronous communication interface adapter for serial data transfer to and from the A2 board. Data transfer to and from the A1 and A9 boards is via an 8-bit-parallel data bus.

The A1 board contains the interface for data transfer between the A2 and A10 boards. It also contains an 8-bit to 16-bit I/O converter, a data buffer, a display data latch, a display RAM, and various control circuits for the 1345A Digital Display.

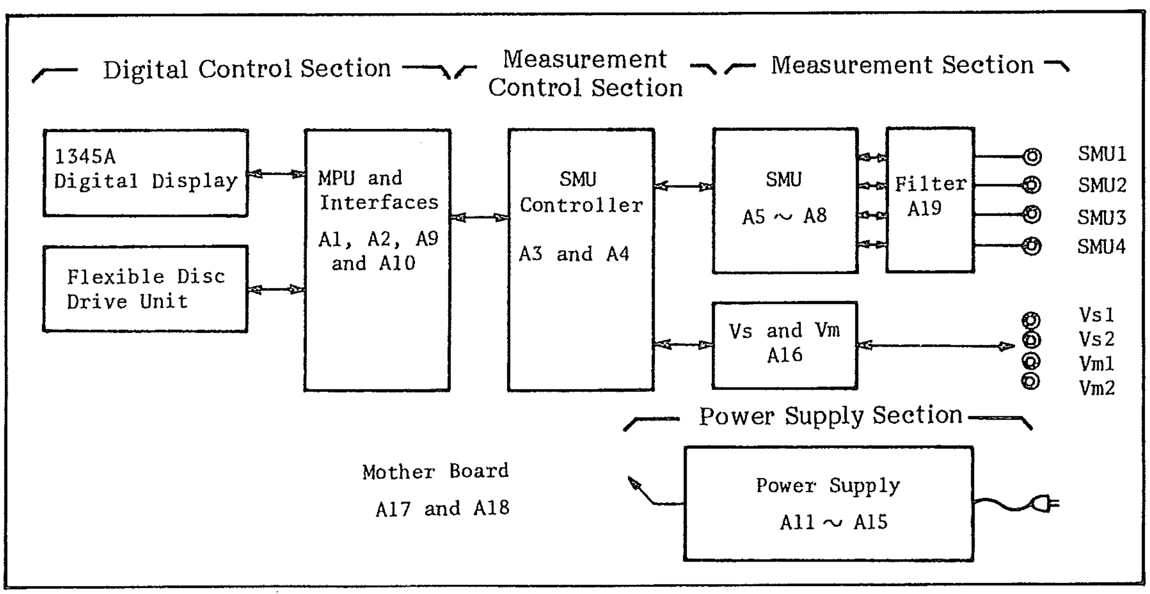


Figure 8-1. Four Major Sections of the 4145A.

The A9 board is divided into two sections: (1) HP-IB control and (2) flexible-disc drive control. Each section has its own control IC which handles data transfer operations.

The A10 board is located behind the front panel, and contains the rotary pulse generator for marker control, and various keys and LEDs. Key depressions and rotations of the rotary pulse generator are encoded by the circuits on the A10 board, and then output to the A2 microprocessor via the data bus interface on the A1 board.

The flexible-disc drive accepts a 5-inch disc which functions as the 4145A's mass storage unit. Read/Write operations are controlled by the A2 microprocessor via the flexible-disc drive control IC on the A9 board, which converts the 8-bit parallel data into serial data.

(4) Power Supply Section :

This section consists of the A11 through A15 boards, and provides the required DC power for the floating and grounded sections. The A11 Switching Power Supply converts line voltage into high frequency (23kHz) pulses. This allows the use of a smaller power transformer, without sacrificing power output capability. In addition to the switching circuits, the A11 board contains a power on detection circuit which resets the A2 and A3 microprocessors, and a power loss detection circuit. The A12 DC Power-Supply rectifies the pulses from the A11 board, and provides the filtering and regulation for the 5V, 12V, and 15V used by the instrument's grounded circuits. The A15 board is the power supply for the floating circuits. It provides +5V, -15V, and +15V for the measurement control section and the measurement section, and ±130Vdc, ±60Vdc, ±40dc, and low level ac for the A13 and A14 SMU power sources.

The A13 and A14 boards are identical, and each provides the voltages necessary to drive two SMUs. A13 drives A5 and A6; and A14 drives A7 and A8.

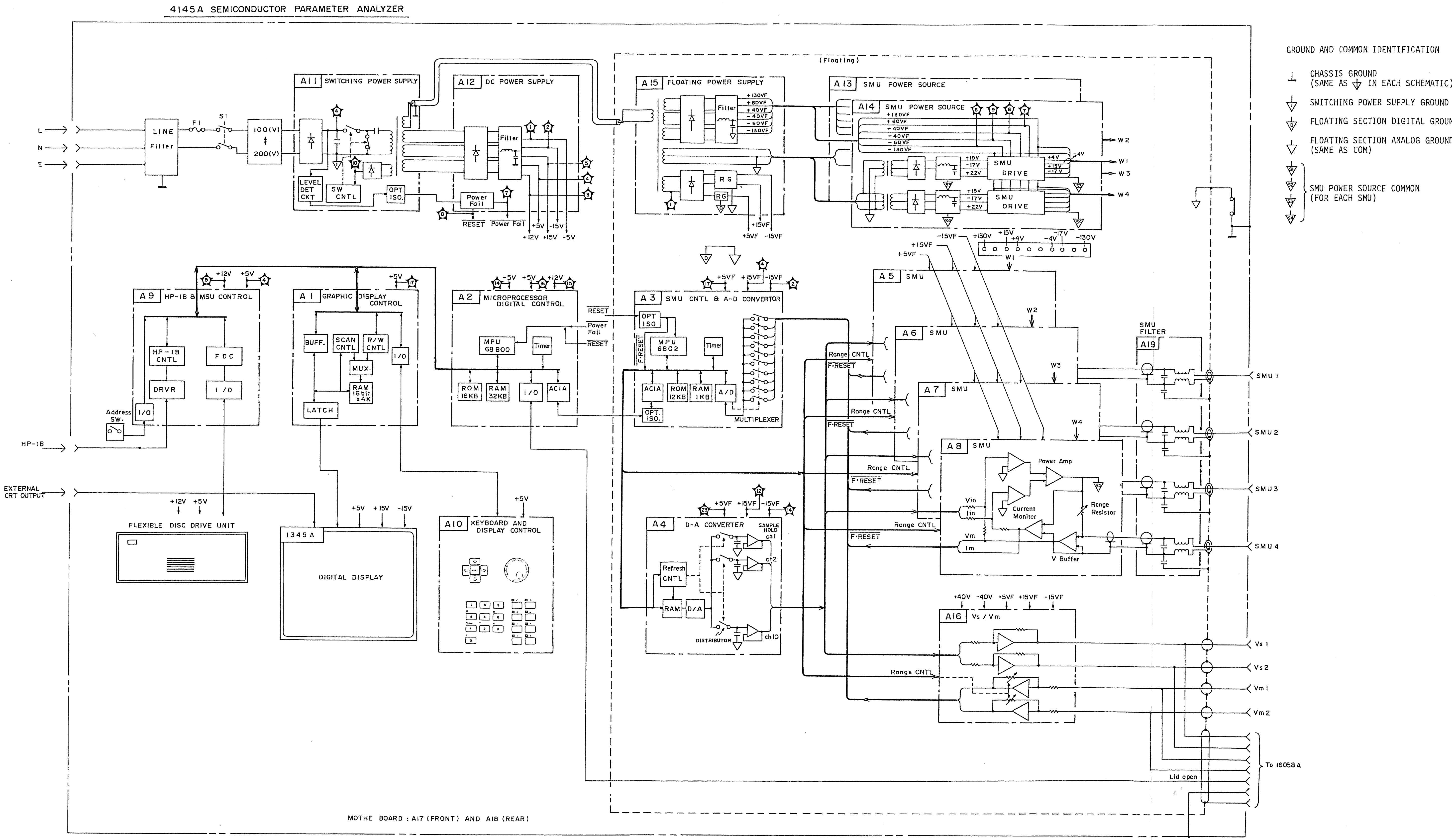


Figure 8-2. Overall Block Diagram.

Table 8-1. Hardware-related Error Codes

Error Code	Meaning	
ROM errors (Did not pass the check-sum test.)		
Error P01 ~ P04	P01: A2U26 P02: A2U27	P03: A2U13 P04: A2U14
RAM errors (Did not pass the read/write test.)		
Error P05 ~ P20	P05: A2U5 P06: A2U6 P07: A2U7 P08: A2U8 P09: A2U9 P10: A2U10 P11: A2U11 P12: A2U12	P13: A2U18 P14: A2U19 P15: A2U20 P16: A2U21 P17: A2U22 P18: A2U23 P19: A2U24 P20: A2U25
IRQ Circuit errors (*: Appears only when the test ROM is used.)		
Error P21	The timer status flip-flop (A2U40A) is not set or reset.	
P22*	IRQ signal from A2U40A is disabled.	
P23*	The ACIA (A2U58) loop back test failed.	
P24*	IRQ signal from A2U58 is disabled.	
P25*	IRQ signal disabled.	
MSU (Mass Strage Unit: FDD and Disc) errors		
Error M08	Spare directory was read.	
M09	Neither main nor spare directory can be read.	
M10	Directory can not be rewritten.	
M11	Data in the RAM and data written onto the disc are not identical.	
M12	Time out error.	
M13	Track 00 signal was not detected.	
M14	The specified track signal can not be detected.	
M15	Track address can not be detected.	
M16	CRC (Cyclic Redundancy Check) error.	
M17	Incorrect handshake timing.	
M18	Write operation was shut down.	
M02	FDD Ready signal was not detected.	
SMU control circuit error		
Error A01	SMU control circuit (A3 and A4) is not functioning properly.	

8-15. TROUBLESHOOTING GUIDE

8-16. Board level isolation of most instrument failures can be quickly accomplished by using the troubleshooting flow diagram of Figure 8-3. Turn the 4145A off and follow the instructions given in the flow diagram. When the faulty board has been isolated, proceed to the component level troubleshooting flow diagram for that board. Table 8-1 lists error codes related to certain hardware failures and can be used for quick failure isolation. Table 8-2 lists SMU status.

Note

One of the error codes listed in ...e 8-1 and 8-2 may be displayed if the instrument is turned on after experiencing an extreme change of ambient temperature. In this case, allow the instrument to fully warm up (ignor the displayed error code), and then turn it off and on one time.

Table 8-2. SMU Status

Display	Meaning	
CHAN (!!!DOWN!!!)	SMU control circuit (A3 and A4) is not functioning properly.	
CHAN (xx, xx, xx, xx)	xx Error Code Channel No.	0: No error 1: V offset error 2: I offset error 3: I leak 4: V range error 5: I range error 6: Iin offset error 7: Loop Change Detector error

Note

When the faulty board has been isolated, proceed to the component level troubleshooting flow diagram for that board. If the failure is in the A1, A2, A3, A4, A9 or A10 board, see Figure 8-12 Digital Section Troubleshooting Notes, first.

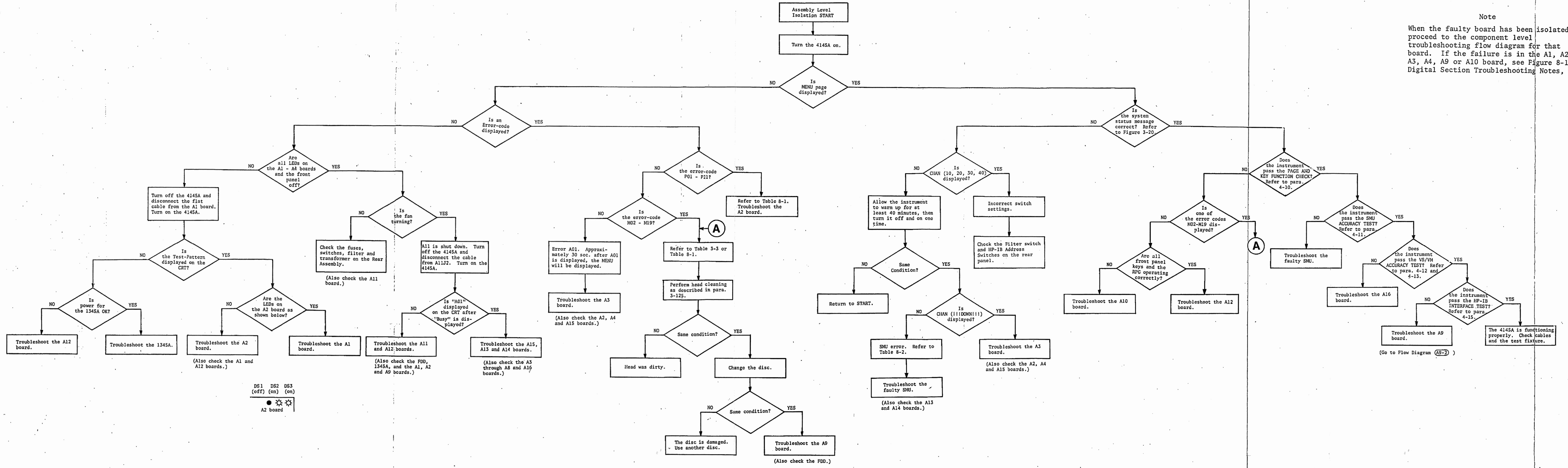
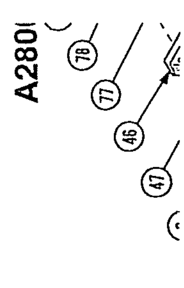


Figure 8-3. Assembly Level Trouble Isolation Flow Diagram.


A280
78
77
46
47

8-17. ASSEMBLY REMOVAL

WARNING

DISCONNECT THE INSTRUMENT FROM THE AC SOURCE BEFORE PROCEEDING WITH ASSEMBLY REMOVAL.

CAUTION

BOTH INCH AND METRIC HARDWARE ARE USED IN THIS INSTRUMENT.

8-18. ASSEMBLY LOCATIONS

8-19. Assembly locations are shown in Figure 8-2.

The A11 and A12 boards are mounted on rear assembly A; the A19 board is mounted on rear assembly B. Refer to Figures 8-7 and 8-9, respectively.

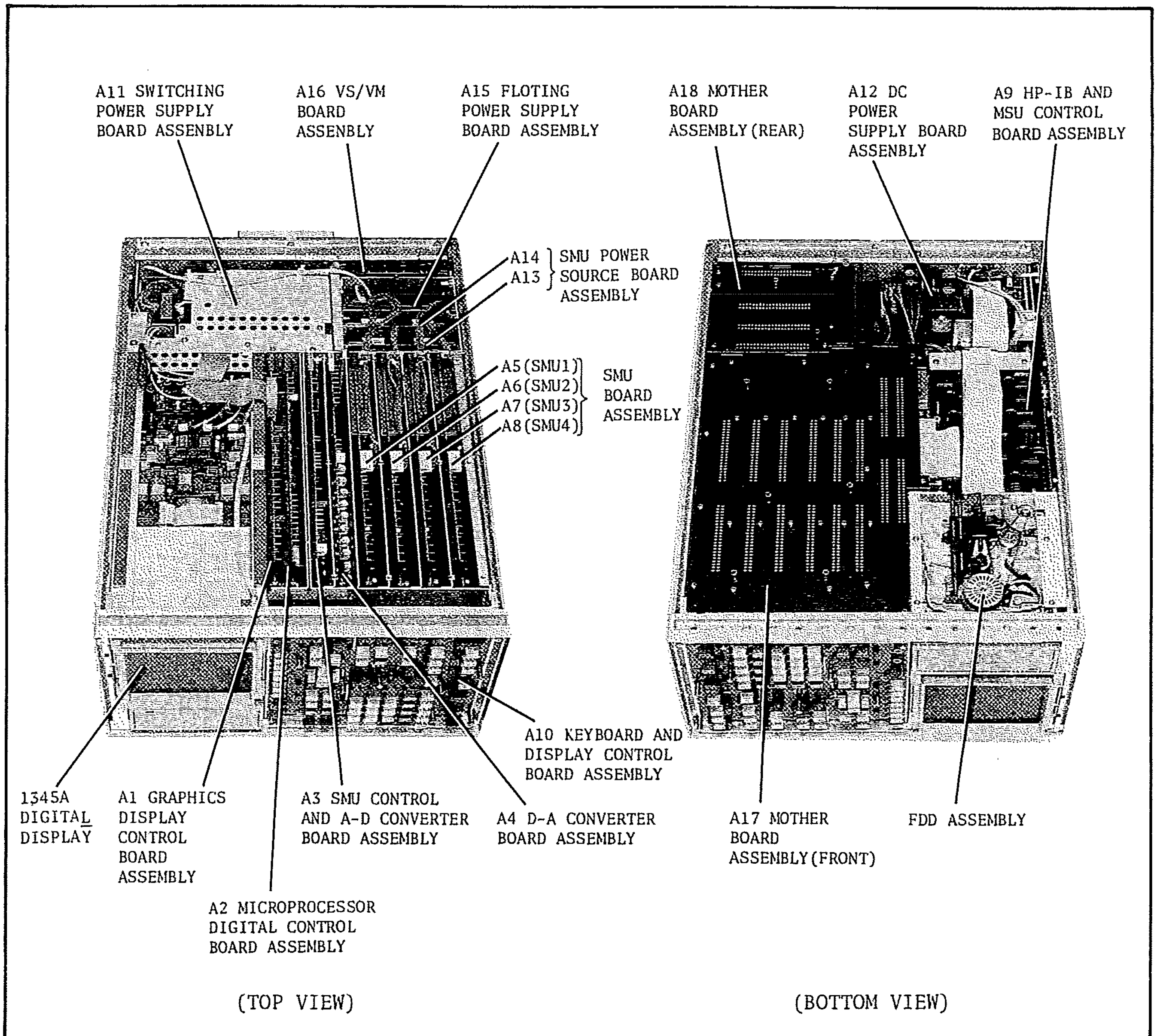


Figure 8-4. Assembly Locations.

8-20. A1 THROUGH A8 BOARD REMOVAL

8-21. To remove the A1 through A8 boards, perform as follows:

(1) Remove the top cover.

(2) Remove the large shield plate.

(3) To remove the A2, A3 or A4 boards, grasp the color-coded tabs mounted on the ends of each board and pull up. To remove the A1 board, first disconnect the blue flat-cable and then use the color-coded tabs to pull the board from its slot. To remove the A5, A6, A7 or A8 board, first raise the board halfway out of its slot and disconnect the cables from J1 and J2, then pull the board from its slot.

Note

The A5, A6, A7 and A8 boards are identical, and, as such, have the same color-coded tabs.

8-22. A13 THROUGH A16 BOARD REMOVAL

8-23. To remove the A13 through A16 boards, perform as follows:

(1) Remove the top cover.

(2) Remove the small plate covering the boards.

(3) To remove the A16 board, grasp the color-coded tabs mounted on the ends of the board and pull up. To remove the A15 board, first disconnect the cable from A11J2 and then use the color-coded tabs to pull the A15 board from its slot. To remove the A13 or A14 board, first disconnect the cables from J1 and J2, and then use the color-coded tabs to pull the board from its slot.

8-24. FRONT PANEL REMOVEL

8-25. To remove the 1345A or the A10 board, the front panel must first be removed. To remove the front panel, perform as follows:

(1) Remove the screws from each corner of the front panel.

(2) Remove the Marker Control Dial. Use a .062mm Hex Driver.

(3) Remove the front panel as shown in Figure 8-5.

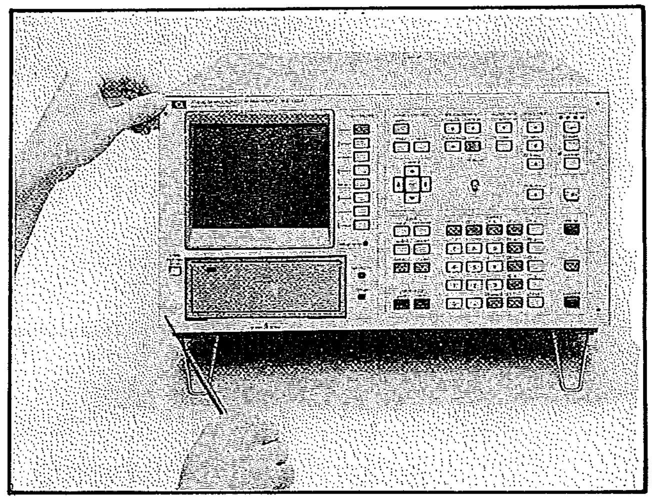


Figure 8-5. Front Panel Removel.

8-26. DISPLAY (1345A) REMOVAL

8-27. To remove the 1345A, perform as follows :

(1) Remove the top cover.

(2) Remove the large shield plate.

(3) Remove the front panel (refer to paragraph 8-25).

(4) Remove screws (1), (2) and (3). Refer to Figure 8-6 (a).

CAUTION

SCREW (3) IS METRIC. WHEN RE-INSTALLING THE 1345A, BE SURE TO INSERT THIS SCREW INTO THE CORRECT HOLE.

(5) Carefully remove the plastic trim strip from the top of the front frame (use a screwdriver).

(6) Remove the adhesive-backed trim strip from the left side of the front frame.

(7) Remove screws (4), (5), (6) and (7). Refer to Figure 8-6 (a).

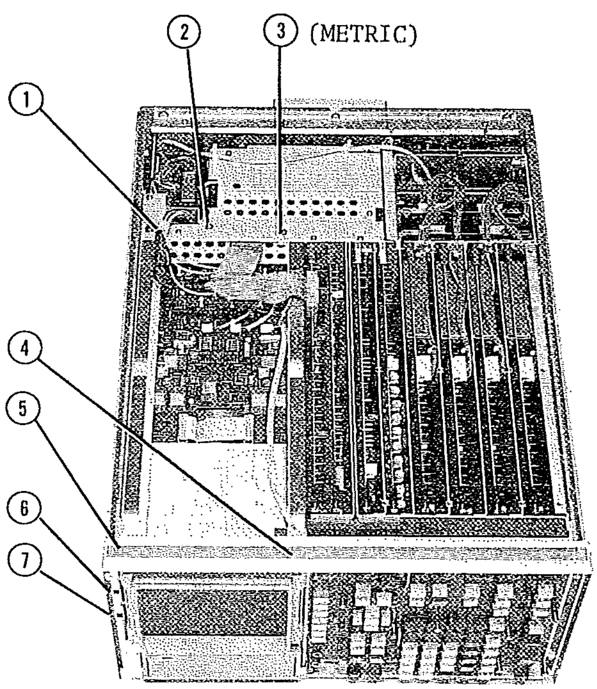
(8) Disconnect the blue flat-cable from the A1 board, and disconnect the focus/intensity control cable and the X, Y, and Z analog output cables from the 1345A.

(9) Carefully slide the 1345A about halfway out of the 4145A as shown in Figure 8-6 (b).

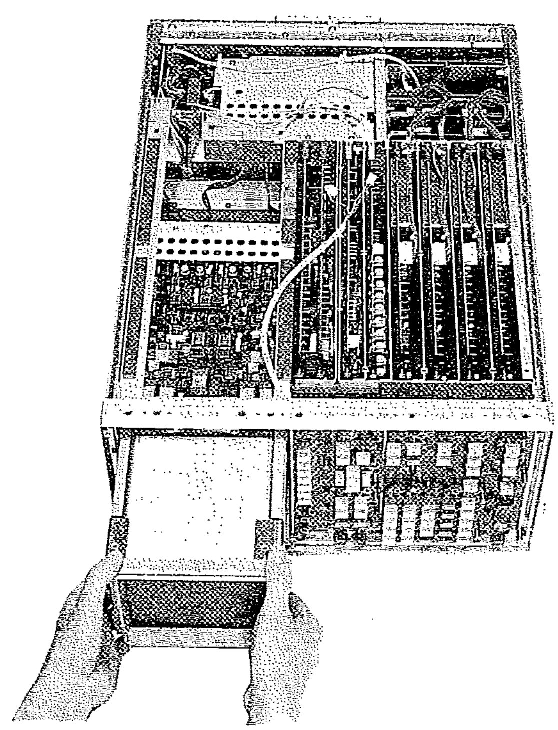
(10) Disconnect the power cable connected to the rear of the 1345A and then slide the 1345A completely out of the 4145A.

Note

The power cable for the 1345A is long enough to permit operation of the 1345A outside the 4145A.



(a) Screw Locations



(b) Removal

Figure 8-6. 1345A Removal.

8-28. REAR ASSEMBLY A REMOVAL

8-29. To remove Rear Assembly A, perform as follows:

(1) Remove the top and bottom covers.

(2) Remove the left side-cover.

(3) Remove screws 1 through 12. Refer to Figure 8-7 (a).

(4) Disconnect all cables.

(5) Carefully pull out the assembly as shown in Figure 8-7 (b).

8-30. A11 AND A12 BOARD REMOVAL

8-31. To remove the A11 and A12 boards, perform as follows:

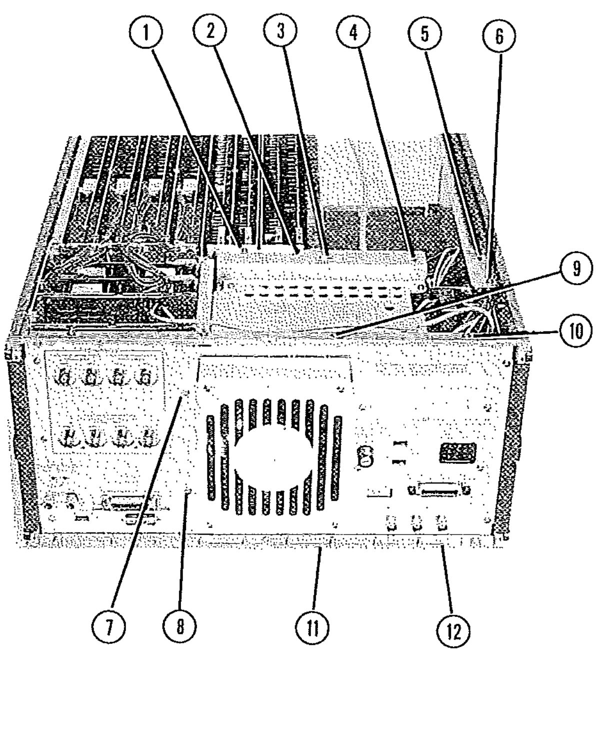
(1) Remove rear assembly A as described in paragraph 8-28.

(2) The A11 or A12 board can be removed by disconnecting all cables and removing the screws that secure the board to the assembly. Refer to Figure 8-8 (a).

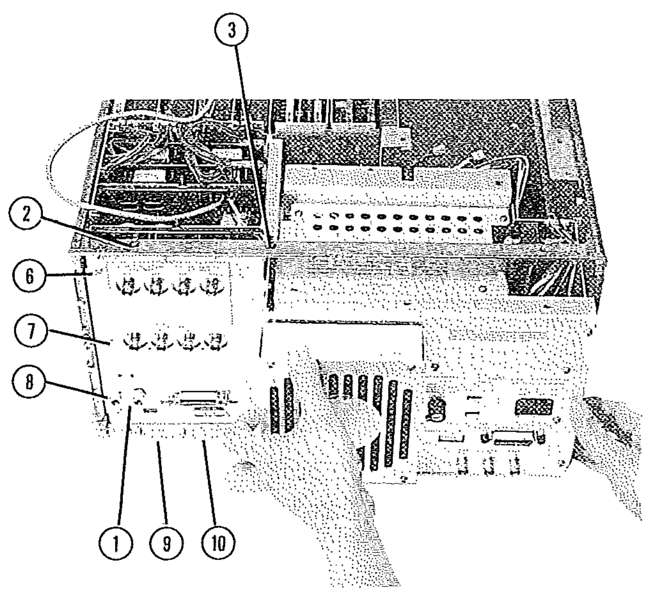
(3) If screws 1 through 5 shown in Figure 8-8 (a) are removed, the line filter can be accessed, as shown in Figure 8-8 (b).

WARNING

POTENTIAL SHOCK HAZARD. DANGEROUS VOLTAGES MAY BE PRESENT ON THE A11 BOARD EVEN AFTER THE 4145A HAS BEEN TURNED OFF.

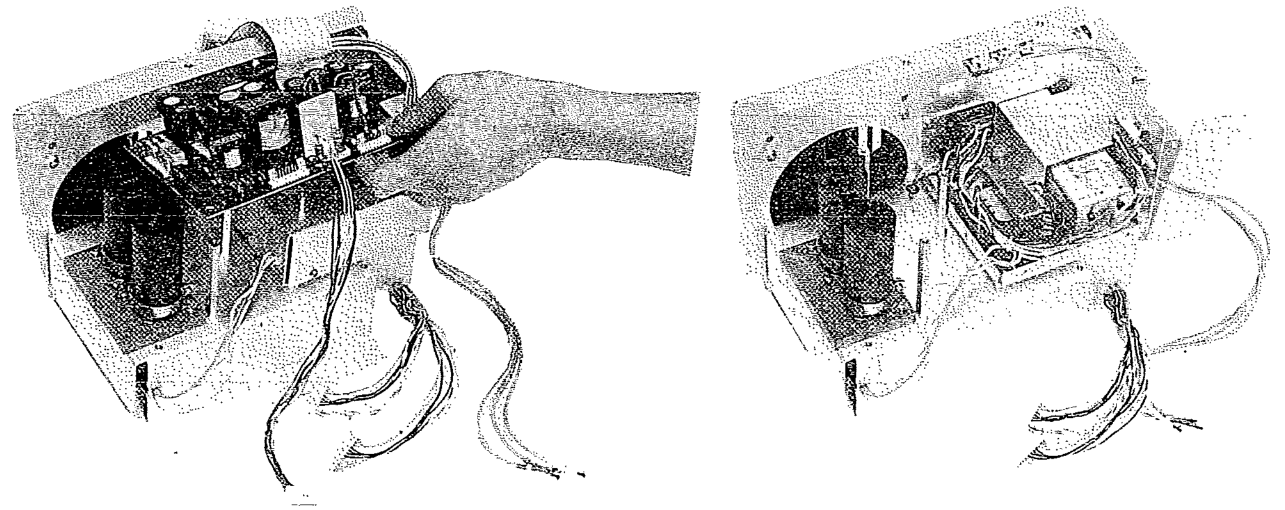


(a) Screw Locations



(b) Removal

Figure 8-7. Rear Assembly A Removal.



(a) A12 Board Removal (b) Line Filter Circuit

Figure 8-8. A11 and A12 Board Removal.

8-32. REAR ASSEMBLY B REMOVAL

8-33. To remove Rear Assembly B, perform as follows:

(1) Remove Rear Assembly A as described in paragraph 8-28.

(2) Disconnect the Shorting Bar (1 in Figure 8-7 (b)).

(3) Remove screws 2 through 10. Refer to Figure 8-7 (b).

(4) Remove the outer panel.

(5) Remove screws 1 through 5. Refer to Figure 8-9.

(6) To access the A19 board, shown in Figure 8-10, remove the shield plate.

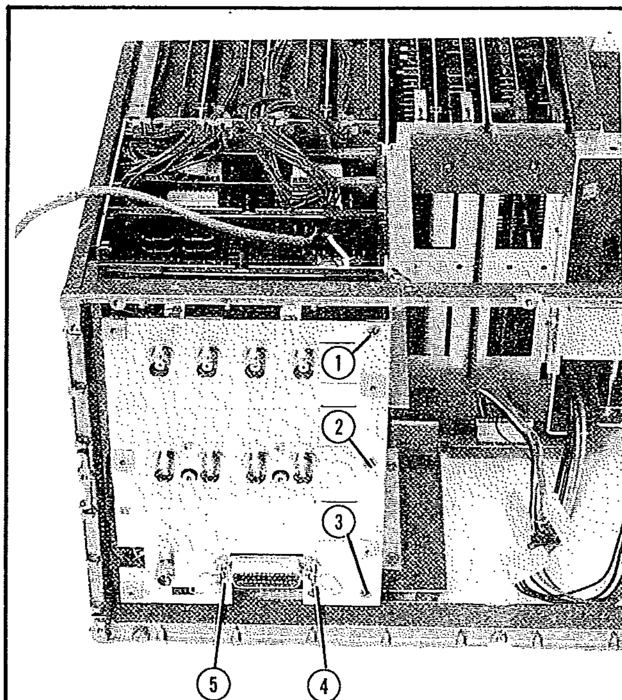


Figure 8-9. Rear Assembly B Removal.

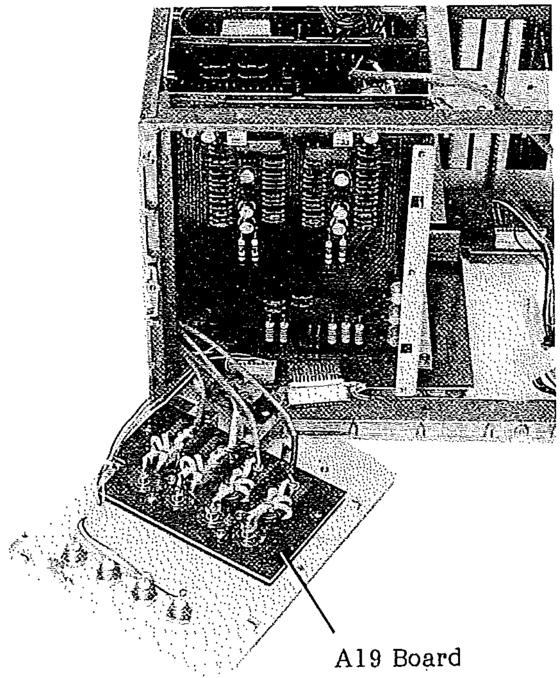


Figure 8-10. A19 Board Assembly.

8-34. FDD AND A9 BOARD REMOVAL

8-35. To remove the FDD (Flexible Disc Drive) and the A9 board, perform as follows :

(1) Remove the bottom cover.

(2) Remove screws (1) through (4) shown in Figure 8-11.

CAUTION

THE FOUR SCREWS ARE METRIC THREADED. BE SURE TO USE THE SAME SCREWS WHEN RE-INSTALLING THE FDD.

(3) Carefully pull out the FDD through the front panel.

(4) Remove the flat cables connected to the A9 board.

(5) Remove the screws securing the A9 board to the chassis.

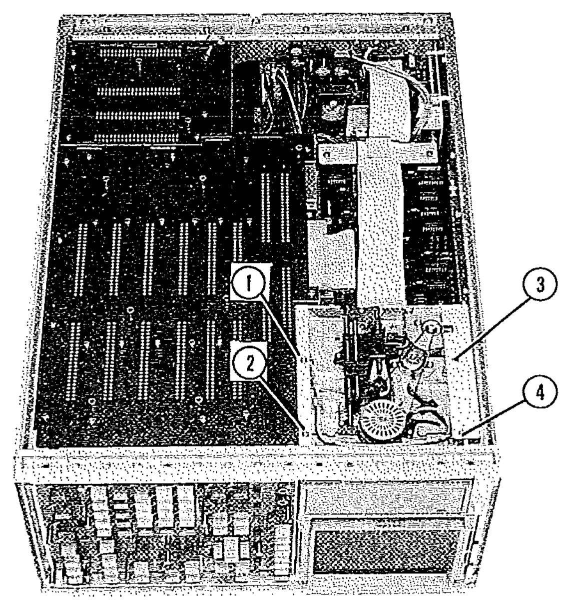


Figure 8-11. FDD and A9 Board Removal.

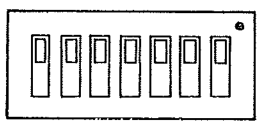
FLOW DIAGRAM NOTES

Digital Section Troubleshooting Notes

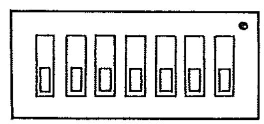
There are fifty-two digital section troubleshooting flow diagrams—six primary and forty-six secondary. A complete listing of all digital section troubleshooting flow diagrams, along with a brief description of each, is given in Table 8-4. These flow diagrams provide the instructions, signature analyzer control settings, and signature analyzer probe and connection points necessary for component level troubleshooting. Signature analysis is used extensively. If you are not familiar with signature analysis, refer to Figure 8-13. It gives a brief description of the technique.

Before troubleshooting the 4145A, there are a few points concerning switch and jumper settings, test ROM usage, etc., that you should be aware of.

1) A2S1 on the A2 board and A3S1 on the A3 board are 7-bit DIP switches that set the 4145A to the appropriate test mode during troubleshooting. During normal operation all bits of A2S1 are set to 1, and all bits of A3S1 are set to 0, as shown below.



A2S1 Normal Setting



A3S1 Normal Setting

NOTE

After troubleshooting has been performed and repairs completed, A2S1 and A3S1 must be set as shown above to allow normal instrument operation.

2) There are twenty-four jumpers, in all, on the A1 through A4 and A9 boards. The settings of these jumpers are changed to set the 4145A to the appropriate test mode as occasion calls while troubleshooting the 4145A. The correct jumper settings are given in the Flow Diagrams. The normal setting for each jumper is pictorially given in Table 8-3, along with a brief description.

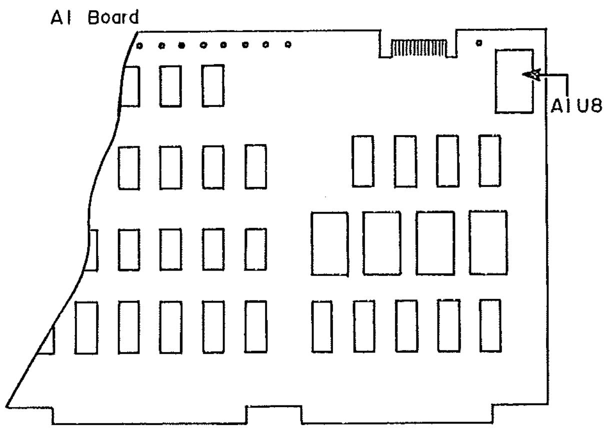
NOTE

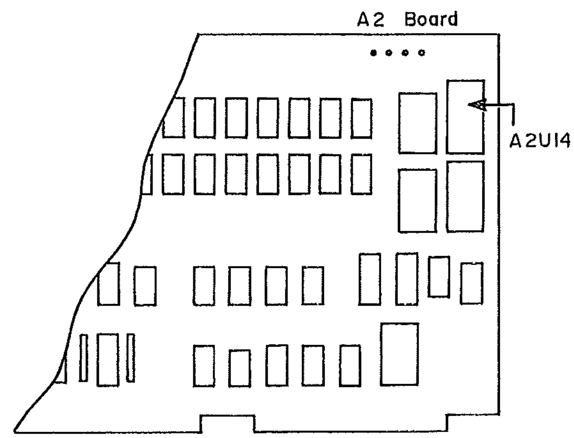
After troubleshooting has been performed and repairs completed, each jumper must be set to its normal setting to allow normal instrument operation.

3) The 4145A is equipped with a special Test ROM which contains the programs necessary to exercise the digital circuits on the A1, A2 and A9 boards. During normal instrument operation, the Test ROM is installed in a dummy socket (A1U8) on the A1 board. For certain troubleshooting procedures, however, it must be installed in the A2U14 socket on the A2 board, as shown in the figure on page 8-15. Instructions on when to use the Test ROM are given in the flow diagrams.

Figure 8-12. Flow Diagram Notes (Sheet 1 of 5).

FLOW DIAGRAM NOTES





NOTE

After troubleshooting has been performed and repairs completed, the Test ROM must be removed from the A2U14 socket and re-installed in the dummy socket on the A1 board, and the standard A2U14 ROM must be installed on the A2 board.

4) The flat-cable connected between the FDD (flexible-disc drive) PC board and the A9 board must be disconnected and then connected to the mother board (A17 board) as instructed in troubleshooting flow diagram when troubleshooting the A9 board. The procedure for connecting the cable to the A17 board is described below :

1) Turn off the 4145A and remove the bottom cover.

2) Remove the flexible-disc drive and disconnect the flat-cable from FDD PC board.

3) Connect the cable to the A17 board as shown below :

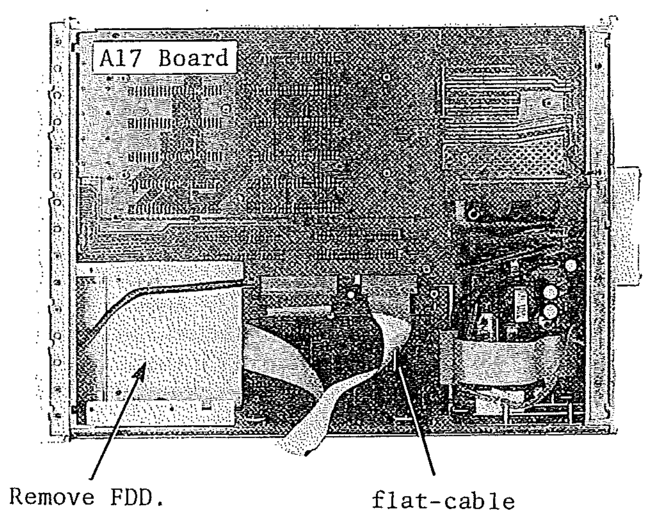


Figure 8-12. Flow Diagram Notes (Sheet 2 of 5).

FLOW DIAGRAM NOTES

Troubleshooting Flow Diagram Notes

Flow Diagram (A2 - 1)

START

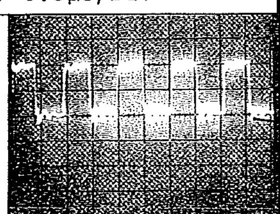
Indicates the lead-in, or initial, troubleshooting flow diagram for a faulty board isolated by the Assembly Level Isolation Flow Diagram. If the Assembly Level Isolation Flow Diagram instructs you to troubleshoot the A2 Board, for example, go to the flow diagram labelled A2-1. Do not go directly to a higher-numbered flow diagram--A2-2 or A2-3, for example. Higher-numbered flow diagrams, if any, originate only from the lead-in flow diagram.

Is the 0.96MHz clock signal shown below present at A3U23-pin 12? (1)

(2) CH--A (DC, INT)
2V/DIV 0.5μs/DIV

YES

0V



(3)

NO

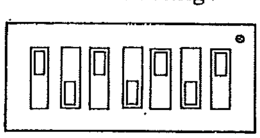
(1) Compare the actual (observed) clock signal with the one given in the figure ((3)).

(2) Connect channel A of the 1740A (recommended oscilloscope) to A3U23-pin 12. Set the 1740A's controls as follows :

COUPLING	DC
DISPLAY	Channel A
TRIGGER	INT
VOLT/DIV	2
TIME/DIV	0.5 μs

Jumper and switch settings:

A3W1: H
A3W4: T (1)
A3S1 setting:



(2)

(1) Set the listed jumpers to the indicated settings. In the example given, A3W1 should be set to H, and A3W4 to T. Leave all other jumpers as they are, change the settings of those listed only. After troubleshooting has been performed and repairs completed, be sure to set all jumpers to their normal settings (refer to Table 8-3).

(2) Set the bit-switches of the indicated switch as shown. In the example given, A3S1 should be set to 1010101. After troubleshooting, set A2S1 and A3S1 to their initial settings (refer to the figure on page 8-14).

Figure 8-12. Flow Diagram Notes (Sheet 3 of 5).

FLOW DIAGRAM NOTES

Signature Analyzer Setting:

START: ⟍ A2U52-pin 1 (2)
STOP: ⟋ A2U52-pin 19 (3)
CLOCK: ⟍ A2TP9 (4)
WINDOW: 3951 (+5V) (5)

(1) Set the Signature Analyzer's START, STOP and CLOCK controls as indicated (⟋: ▨ OUT) (⟍: ▨ IN).

(2), (3), (4)

Connect the START, STOP and CLOCK leads of the Signature Analyzer's active pod to the indicated points. In the example given, START should be connected to A2U52-pin 1, STOP to A2U52-pin 19, and CLOCK to A2TP9.

(5) This is the signature for the window test (+5V). It should be displayed on the signature analyzer. If the correct signature is not displayed, press the RESET button on the probe. If the window is still incorrect, check the component from which the window signal or clock signal is taken. In the example given, A2U52 and the component directly connected to A2TP9.

Is the signature at A2U37-pin 6 "755H"? YES / NO

Check that the signature at A2U37-pin 6 is 755H.

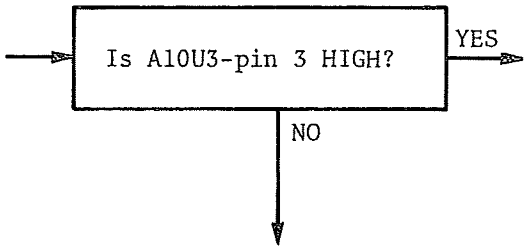
Is the following signature set correct? YES / NO

Test Point	Signature
A2U35-pin 7	76U2
pin 9	PU48
pin 10	FP98
pin 11	U229

Check that the signature set shown is correct.

Figure 8-12. Flow Diagram Notes (Sheet 4 of 5).

FLOW DIAGRAM NOTES



Check that the logic level at A10U3-pin 3 is HIGH.

Figure 8-12. Flow Diagram Notes (Sheet 5 of 5).

Table 8-3. Jumper Settings (Sheet 1 of 2)

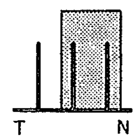
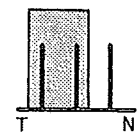
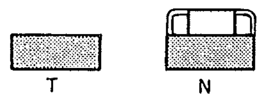
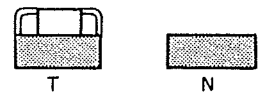
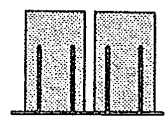
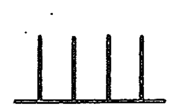
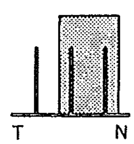
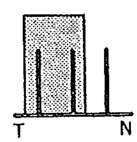
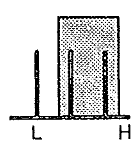
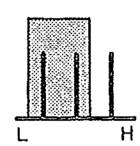
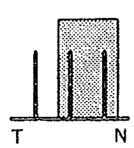
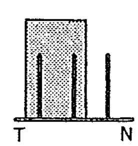
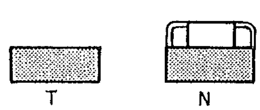
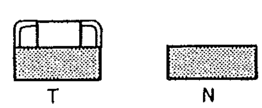
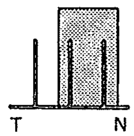
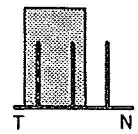
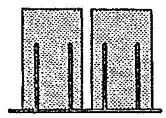
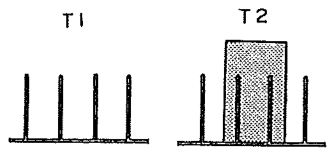
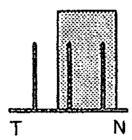
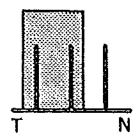
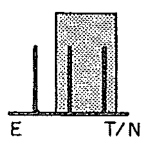
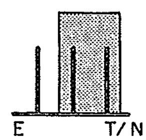
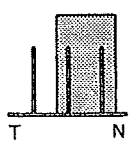
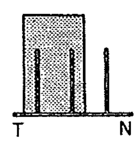
Reference Designation	Normal Setting	Test Setting	Note
A1W1 A1W2 A1W3 A1W4 A1W5			
A2W1			
A2W2 A2W3			There are two states for A2W2 and A2W3, respectively. 1) Jumper removed for test setting. 2) Jumper installed for normal setting.
A2W4			
A3W1			
A3W2 A3W3 A3W4			
A3W5			

Table 8-3. Jumper Settings (Sheet 2 of 2)

Reference Designation	Normal Setting	Test Setting	Note
A3W6 A3W7			
A3W8•9			There are two test settings for A3W8•9: T1 and T2.
A4W1 A9W1 A9W2			
A9W3			T/N: Test/Normal E: Exerciser E-position is used to set the 4145A to the MSU DIAGNOSTICS Mode.
A9W4 A9W5			

Note:

T:	Test
N:	Normal
L:	LOW
H:	HIGH
T/N:	Test/Normal
E:	EXERCISER

Signature Analysis

Signature Analysis is a unique technique for component-level troubleshooting. The signature analyzer detects and displays the unique digital signature of the data at a given node in the circuit under test. By comparing the actual signature to the correct one, the service technician can quickly back-trace to the faulty node, and, ultimately, to the faulty component. To represent the signature, a nonstandard character set (123456789 ACFHPU) was chosen for readability and compatibility with 7-segment displays.

Stated simply, the signature analyzer displays a compressed four-digit "fingerprint" of the data stream present at a node. This "fingerprint" is unique for a good node. Any fault associated with a device on that node will force a change in the data stream and, consequently, result in an incorrect signature. If, for example, the signature at the input of a device is correct but the signature at the output is not, the device is regarded as faulty and should be replaced.

This technique is especially useful in troubleshooting microprocessor based instruments like the 4145A, where data streams are long and complex and where there are no conventional means to efficiently troubleshoot to the component level.

The signature analyzer's active logic probe and active pod detect and develop the signature for display on the signature analyzer. The logic probe is applied to the desired node in the circuit under test and transfers the data to the signature analyzer. The four leads on the active pod are connected to appropriate points on the 4145A, and provide the necessary START, STOP, and CLOCK signals and GND reference. The START signal opens the measurement "window" and instructs the signature analyzer to prepare to receive data from the logic probe; the STOP signal closes the "window." The CLOCK signal provides the appropriate measurement timing pulses. Probe points; connection locations for START, STOP, and CLOCK; and control settings for the signature analyzer are given in the troubleshooting flow diagrams.

MEASUREMENT GATING EXAMPLE, POSITIVE EDGE START, STOP, AND CLOCK

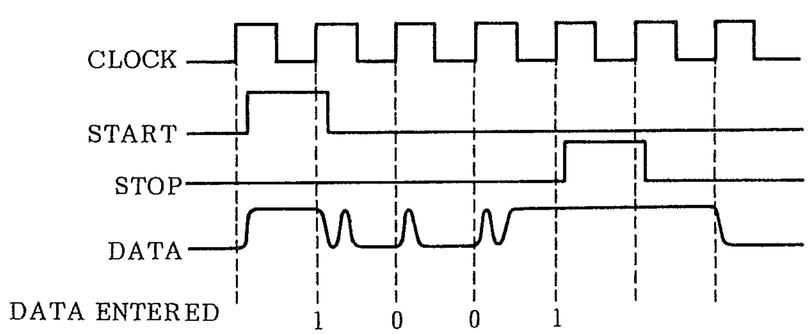


Figure 8-13. Signature Analysis.

Table 8-4. List of Digital Section Troubleshooting Flow Diagrams (Sheet 1 of 3)

Flow Diagram	Description (Purpose)
Flow Diagram (A1 - 1)	Contains the 1345A SELF Test and checks the clock signals and data bus lines (IOD0 through IOD7)
Flow Diagram (A1 - 2)	Contains A1 Board Self Test (Memory Pointer Test, Read/Write Test, Handshake Test and Jump Test), and indicates whether the Memory R/W Control, Handshake Control, Jump Control, Memory R/W Pointer, MPX, Static RAM or Output Latch is defective.
Flow Diagram (A1 - 3) **Flow Diagram (A1 - 4)**	Checks the Read/Write operation of the Memory R/W Control circuit, Memory R/W Pointer circuit, MPX circuit and Static RAMs.
Flow Diagram (A1 - 5)	Checks the Handshake Control circuit, Scan Pointer circuit, MPX circuit and Output Latch circuit for correct handshake between the 1345A and the A1 board.
Flow Diagram (A1 - 6)	Checks the Jump Control circuit and Scan Pointer circuit.
Flow Diagram (A2 - 1) **Flow Diagram (A2 - 2)**	Checks the dc voltage supplied from the A12 board, clock signals, and DBE signal.
Flow Diagram (A2 - 3)	Isolates instrument failures to ROM-related circuits, RAM-related circuits, Timer circuit or the ACIA (Asynchronous Communication Interface Adapter).
Flow Diagram (A2 - 4)	Checks the Clock Generator (A2U15) and the Address Decode & Wait circuit.
Flow Diagram (A2 - 5) **Flow Diagram (A2 - 6)** **Flow Diagram (A2 - 7)** **Flow Diagram (A2 - 8)**	Checks the ROMs (A2U13, U14, U26 and U27), MPU, address bus and data bus.
Flow Diagram (A2 - 9) **Flow Diagram (A2 - 10)** **Flow Diagram (A2 - 11)**	Checks the RAMs (A2U5 through A2U12 and A2U18 through A2U25), Dynamic Memory Refresh and Control circuit (A2U16 and U17).
Flow Diagram (A2 - 12)	Checks the Clock Divider circuit (including A2U46, U48 and U49) and Timer (A2U40).

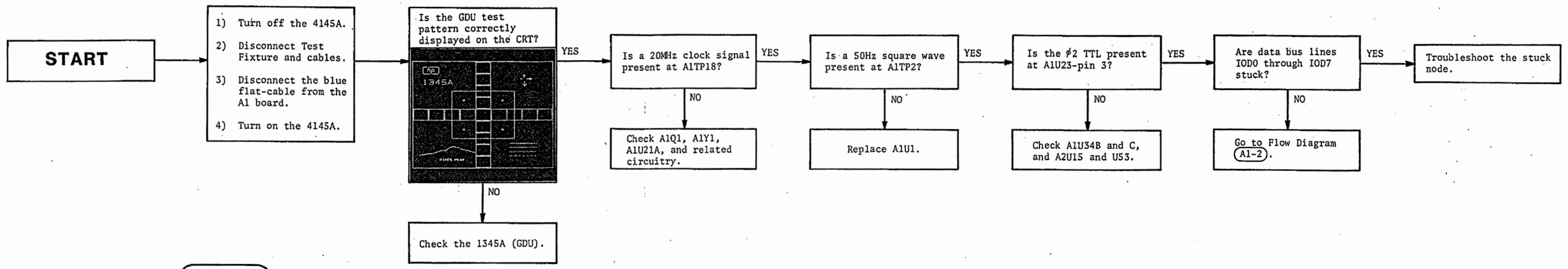
Table 8-4. List of Digital Section Troubleshooting Flow Diagrams (Sheet 2 of 3)

Flow Diagram	Description (Purpose)
Flow Diagram A2 - 13	Checks the ACIA (A2U58) and A2U57.
Flow Diagram A3 - 1 Flow Diagram A3 - 2	Checks the dc voltage supplied from the A15 board, checks the clock and reset signals used by the MPU, and contains the A3/A4 board Self Test, which indicates a defective A3/A4 circuit by the A3DS1 through A3DS4 (LEDs) display pattern.
Flow Diagram A3 - 3	Checks the ROMs (A3U9, U10 and U11) by performing the ROM Check Sum Test.
Flow Diagram A3 - 4	Checks the RAMs (A3U24 and A3U25) by performing the RAM Pattern Test.
Flow Diagram A3 - 5 Flow Diagram A3 - 6 Flow Diagram A3 - 7	Checks the Interval Timer circuit (A3U5, U18 and U19) and the interrupt signal flow to the MPU.
Flow Diagram A3 - 8 Flow Diagram A3 - 9 Flow Diagram A3 - 10 Flow Diagram A3 - 11	Checks the A-D Converter circuit.
Flow Diagram A3 - 12 Flow Diagram A3 - 13	Checks ACIA (Asynchronous Communication Interface Adapter, A3U44) and the optocouplers, which handle data transfer between the host processor (A2 board) and the A3 board.
Flow Diagram A4 - 1 Flow Diagram A4 - 4	Checks the Multiplex Timing Controller circuit.
Flow Diagram A4 - 2	Checks the MPU Bus Interface (A4U35, U36 and U37) and Data Memory (A4U19, U20, U25 and U26).
Flow Diagram A4 - 3	Checks the D-A converter circuit, including A4U18 and the I/V Converter circuit.

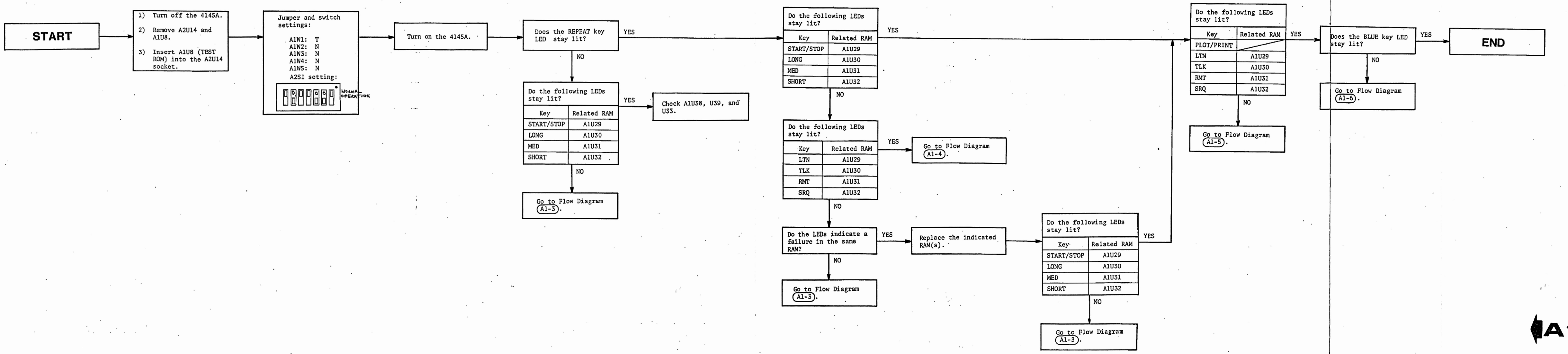
Table 8-4. List of Digital Section Troubleshooting Flow Diagrams (Sheet 3 of 3)

Flow Diagram	Description (Purpose)
Flow Diagram (A4 - 5) **Flow Diagram (A4 - 6)**	Checks the Analog Demultiplexer S/H Switching circuit and S/H Amplifier circuit.
Flow Diagram (A9 - 1)	Checks the dc voltage supplied from the A12 board and isolates failures in the MSU (Mass Storage Unit).
Flow Diagram (A9 - 2)	Checks all clock signals and gives instructions for further troubleshooting.
Flow Diagram (A9 - 3) **Flow Diagram (A9 - 4)**	Checks the HP-IB Bus Tranceiver circuit (A9U8, U9, U12 and U13) and the HP-IB Interface Adapter (A9U7).
Flow Diagram (A9 - 5)	Checks the HP-IB Address SW Buffer (A9U19) to verify that the HP-IB address switch is correctly read.
Flow Diagram (A9 - 6) **Flow Diagram (A9 - 7)** **Flow Diagram (A9 - 8)** **Flow Diagram (A9 - 9)** **Flow Diagram (A9 - 10)**	Checks the MSU Interface circuit (A9U3, A9U14 through A9U17) and verifies the MSU Interface Write and Step functions.
Flow Diagram (A9 - 11)	Checks A9U14, U16, U17, etc., to verify the MSU Interface Read function.
Flow Diagram (A10 - 1)	Isolates a front panel failure to the LED decode circuit, RPG (Rotary Pulse Generator) control circuit, or Key control/decode circuits. Also checks the LED decode circuit and RPG control circuit.
Flow Diagram (A10 - 2) **Flow Diagram (A10 - 3)**	Checks the Key control/decode circuits.

Flow Diagram (A1 - 1)



Flow Diagram (A1 - 2)



A1 Troubleshooting Flow Diagram

Figure 8-14. A1 Board Troubleshooting Flow Diagram (Sheet 1 of 5).

Flow Diagram A1 - 3

START

Turn off the 4145A.

Jumper and switch settings:

A1W1: N
A1W2: N
A1W3: N
A1W4: T
A1W5: N
A2W3: Removed (off)
A2S1 setting:

Signature Analyzer Setting:

START: ⎰ } A2TP17
STOP: ⎱
CLOCK: ⎱ A2TP13
WINDOW: P906 (+5V)

Turn on the 4145A.

Is the signature at A1U33-pin 19 "PH17"?
NO → Replace A2U36.
YES ↓

Is the signature at A1U33-pin 23 "57A0"?
NO → Replace A2U53.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U33-pin 22	PCUF
pin 21	A289
pin 20	P629

NO → Replace A2U30.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U33-pin 1	9C62
pin 2	P906
pin 3	1A95
pin 4	P906
pin 5	1CF4
pin 6	P906
pin 7	C3A3
pin 8	P906
pin 9	F487

NO → Replace A1U33.
YES ↓

Is the signature at A1U34-pin 10 "P906"?
YES → (next step below)
NO ↓

Is the signature at A1U34-pin 3 "P906"?
YES → Replace A1U34.
NO → Replace A2U53.

Is the following signature set correct?

Test Point	Signature
A1U23-pin 5	2H81
pin 6	F487
pin 8	1A95
pin 9	U393

NO → Check A1U23 and check for a stuck node.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U40-pin 2	223H
pin 17	4U83
pin 4	F9AF
pin 15	3A8H
pin 6	6A1U
pin 13	2P53
pin 8	H860
pin 11	4811

NO → Check for a stuck node.
YES → A

A →

Is the following signature set correct?

Test Point	Signature
A1U40-pin 18	223H
pin 3	4U83
pin 16	F9AF
pin 5	3A8H
pin 14	6A1U
pin 7	2P53
pin 12	H860
pin 9	4811

NO → Check A1U40 and check for a stuck node.
YES ↓

Change Signature Analyzer Setting:
CLOCK ⎱ → CLOCK ⎰

Is the following signature set correct?

Test Point	Signature
A1U22-pin 3	860U
pin 4	860U
pin 5	860U
pin 6	860U
pin 10	860U
pin 11	860U
pin 12	860U
pin 13	860U

NO → Check A1U22 and check for a stuck node.
YES ↓

Is the signature at A1TP14 "90FU".
NO → Check A1U3, U10, U12, U41, and U42.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U25-pin 3	HCPA
pin 2	PHF8
pin 6	78HF
pin 7	A178

NO → Check A1U25 and check for a stuck node.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U26-pin 3	91AS
pin 2	2CC9
pin 6	3CC1
pin 7	U9U3

NO → Check A1U26 and check for a stuck node.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U27-pin 3	51F0
pin 2	C543
pin 6	7549
pin 7	P380

NO → Check A1U27 and check for a stuck node.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U13-pin 4	A8H2
pin 7	844F
pin 9	CC2A
pin 12	52C2

NO → Check A1U13 and check for a stuck node.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U14-pin 4	0283
pin 7	2C5A
pin 9	8FF8
pin 12	702P

NO → Check A1U14 and check for a stuck node.
YES → B

B →

Is the following signature set correct?

Test Point	Signature
A1U15-pin 4	AF41
pin 7	9CC4
pin 9	5168
pin 12	4935

NO → Check A1U15 and check for a stuck node.
YES ↓

Is the signature at A1TP9 "90FU"?
NO → Check A1U11, U29, U30, U31, and U32.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U41-pin 2	5CC3
pin 19	94H0
pin 5	0U5P
pin 16	6195
pin 6	1839
pin 15	7F6C
pin 9	9587
pin 12	8CFC

NO → Check A1U41 and check for a stuck node.
YES ↓

Is the following signature set correct?

Test Point	Signature
A1U42-pin 2	U798
pin 19	2P09
pin 5	8C70
pin 16	7A8U
pin 6	C2C5
pin 15	F5A1
pin 9	A658
pin 12	5456

NO → Check A1U42 and check for a stuck node.
YES ↓

Go to Flow Diagram A1-4.

Figure 8-14. A1 Board Troubleshooting Flow Diagram (Sheet 2 of 5).

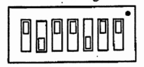
Flow Diagram (A1-4)

START

Turn off the 4145A.

Jumper and switch settings:

A1W1: N
A1W2: T
A1W3: N
A1W4: N
A1W5: N
A2W3: Removed (off)
A2S1 setting:



Signature Analyzer Setting:

START: ⎯/ } A2TP17
STOP: \⎯ }
CLOCK: ⎯/ A2TP13
WINDOW: OHFA (+5V)

Turn on the 4145A.

Is the signature at A1TP17 "OHFA"?

NO → Check DSA Setup.

YES →

Is the following signature set correct?

Test Point	Signature
A1U29-pin 9	CUC4
pin 10	A61F
pin 11	1UC6
pin 13	C27H
pin 14	U098
pin 15	ACCF
pin 16	H6C0
pin 17	UC66

NO → Check A1U29 and U30.

YES →

Is the following signature set correct?

Test Point	Signature
A1U31-pin 9	AUH2
pin 10	P6C5
pin 11	H6F5
pin 13	UHAU
pin 14	C27P
pin 15	19A8
pin 16	C0F3
pin 17	1A85

NO → Check A1U31 and U32.

YES →

Change Signature Analyzer Setting:

CLOCK ⎯/ → CLOCK \⎯

Is the signature at A1U43-pin 1 "U69F"?

NO → Check A1U43 and U33.

YES →

Is the signature at A1U44-pin 1 "C8AP"?

NO → Check A1U44 and U33.

YES →

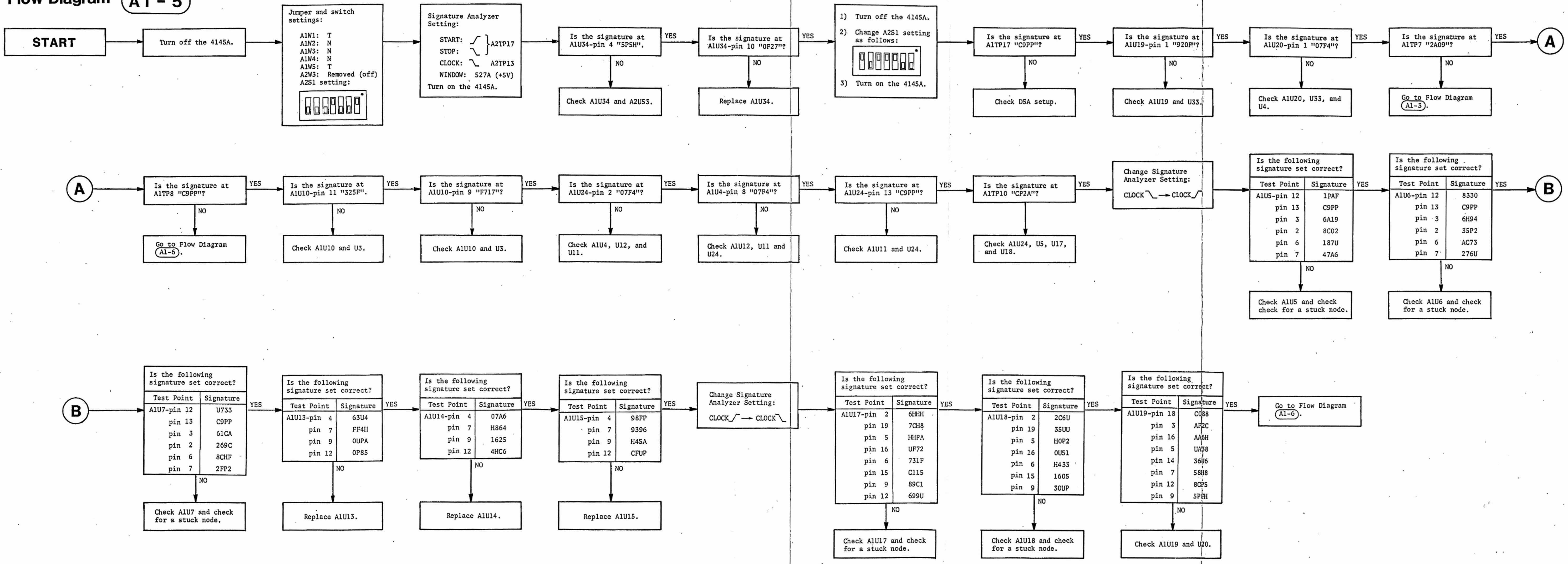
Is the following signature set correct?

Test Point	Signature
A1U43-pin 2	3539
pin 19	78F2
pin 5	72PH
pin 16	0C58
pin 6	6A1A
pin 15	H85F
pin 9	H36U
pin 12	31P9

NO → Check A1U43 and U44.

YES → Go to Flow Diagram (A1-5).

Flow Diagram A1 - 5



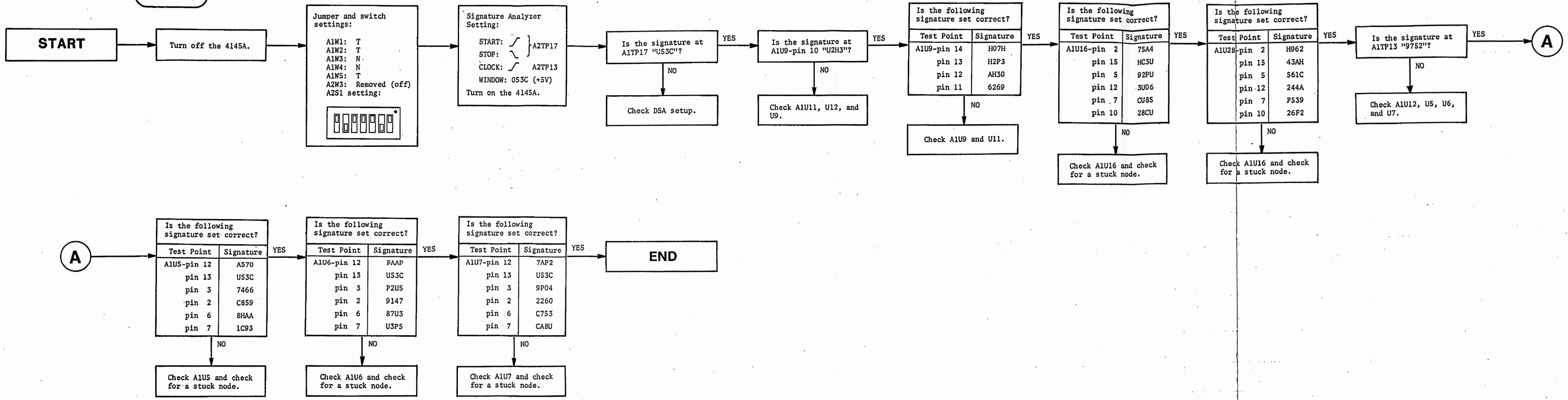
A1 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-14. A1 Board Troubleshooting Flow Diagram (Sheet 3 of 5).

Figure 8-14. A1 Board Troubleshooting Flow Diagram (Sheet 4 of 5).

Flow Diagram A1 - 6



Flow Diagram (A2-1)

START

Is one of the error codes P01 through P04 displayed on the CRT when the 4145A is turned on?

YES → Go to Flow Diagram (A2-5).

NO ↓

Are the following voltages correct?

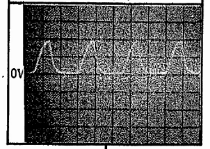
Test Point	Limit
A2TP14	-5V±0.5V
A2TP15	+12V±1.2V
A2TP16	+5V±0.25V

NO → Go to Flow Diagram (A12-1).

YES ↓

Is the signal at A2U15-pin 6 as shown below?

CH--A (DC, INT)
2V/DIV 0.05μs/DIV

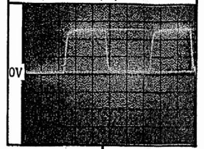


NO → Check A2U15, Y1, C2, and C3.

YES ↓

Is the signal at A2TP9 as shown below?

CH--A (DC, INT)
2V/DIV 0.1μs/DIV

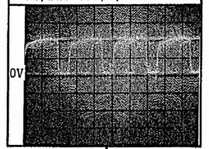


NO → Go to Flow Diagram (A2-4).

YES ↓

Is the signal at A2TP11 as shown below?

CH--A (DC, INT)
2V/DIV 0.2μs/DIV

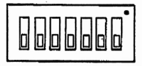


NO → Go to Flow Diagram (A2-2).

YES ↓

1) Turn off the 4145A.
2) Disconnect the test fixture and cables.
3) Remove A1U8 and A2U14.
4) Insert A1U8 (TEST ROM) into the A2U14 socket.

A2S1 setting:



Turn on the 4145A.

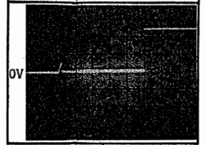
Do the LEDs (A2DS1 through A2DS3) stay lit for approximately 0.5s when the 4145A is turned on?

YES → Go to Flow Diagram (A2-3).

NO ↓

Is the signal shown below present at A2U15-pin 17 when the 4145A is turned on?

CH--A (DC, INT, DGND)
2V/DIV 50ms/DIV



NO → Go to Flow Diagram (A12-1).

YES ↓

Is the same signal observed at A2U15-pin 15 when the 4145A is turned on?

YES → Check the LEDs (A2DS1 through A2DS3).

NO → Replace A2U15.

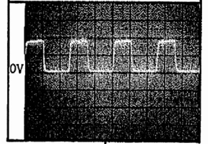
Flow Diagram (A2-2)

START

1) Turn off the 4145A.
2) Remove A2W4.
3) Turn on the 4145A.

Is the signal at A2U15-pin 10 as shown below?

CH--A (DC, INT)
2V/DIV 0.2μs/DIV

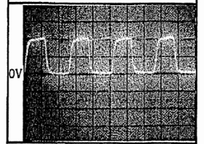


NO → Replace A2U15.

YES ↓

Is the signal at A2U29-pin 4 as shown below?

CH--A (DC, INT)
2V/DIV 0.1μs/DIV

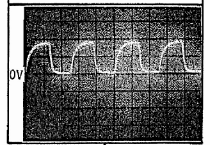


NO → Replace A2U15.

YES ↓

Is the signal at A2U29-pin 6 as shown below?

CH--A (DC, INT)
2V/DIV 0.1μs/DIV

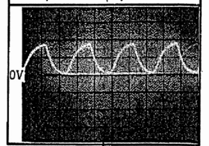


NO → Replace A2U29.

YES ↓

Is the signal at A2U28-pin 10 as shown below?

CH--A (DC, INT)
2V/DIV 0.1μs/DIV



NO → Check A2R10 and C43.

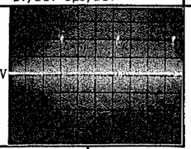
YES → Replace A2U28.

Flow Diagram (A2 - 3)

START

Is one of the error codes P05 through P25 displayed on the CRT?
- YES → Error Code P05 through P20?
  - YES → Replace the RAM that corresponds to the error code. See Table 1. → If the problem persists, go to Flow Diagram (A2-9).
  - NO → Go to the flow diagram that corresponds to the error code. See Table 1.
- NO → Do LEDs A2DS1 through A2DS3 repeatedly cycle through the eight patterns listed in Table 2.
  - YES → Is the signal at A2U16-pin 8 as shown below?

    CH--A (DC, INT)
    .2V/DIV 5μs/DIV

    - YES → **END**
    - NO → Go to Flow Diagram (A2-9).
  - NO → Do the LEDs display one of the patterns in Table 2.
    - YES → Turn off the 4145A. → Signal Analyzer Setting: START: A2TP13; STOP: A2TP13; CLOCK: A2TP9 → Turn on the 4145A. → Is the signature at A2TP16 one of the signatures listed Table 3.
      - YES → ROM or RAM Error → Replace the ROM or RAM that corresponds to the signature at TP16. See Table 3. → If the problem persists, go to the flow diagram that corresponds to signature at TP16.
      - YES → TIMER or ACIA Error → Go to the Flow Diagram that corresponds to signature at TP16. See Table 3.
      - NO → Go to Flow Diagram (A2-5).
    - NO → Is the A2S1 setting correct?
      - YES → Go to Flow Diagram (A2-5).
      - NO → Correct the setting, then return to START.

Table 1

Error Code	Related RAM	Flow Diagram
P05 P06 P07 P08 P09 P10 P11 P12 P13 P14 P15 P16 P17 P18 P19 P20	A2U5 A2U6 A2U7 A2U8 A2U9 A2U10 A2U11 A2U12 A2U18 A2U19 A2U20 A2U21 A2U22 A2U23 A2U24 A2U25	A2-9
P21 P22		A2-12
P23 P24		A2-13
P25		A2-12

Table 2

No.	Pattern A2DS1	Pattern A2DS2	Pattern A2DS3
1	○	○	○
2	●	●	●
3	●	●	○
4	●	○	●
5	●	○	○
6*	○	●	●
7	○	●	○
8	○	○	●

○: ON
●: OFF

*: A2DS1 blinks for approximately 10s.

Table 3

Signature	Related IC	Error	Flow Diagram
1670 9F15 0560 5837	A2U26 A2U27 A2U13 A2U14	ROM	A2-5
0HH4 751C 46H8 C602 808C 9562 5892 2490 243P 0UCP PUAA PA9A A6C1 AF42 108F P01U	A2U 5 A2U 6 A2U 7 A2U 8 A2U 9 A2U10 A2U11 A2U12 A2U18 A2U19 A2U20 A2U21 A2U22 A2U23 A2U24 A2U25	RAM	A2-9
07FC U2UH		TIMER	A2-12
CU69 HA74		ACIA	A2-13
9H14		TIMER	A2-12

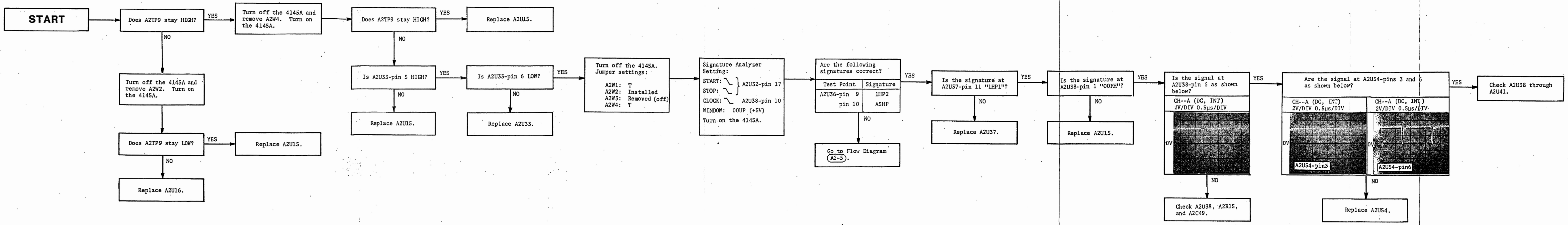
A2 Troubleshooting Flow Diagram

SEE INSIDE

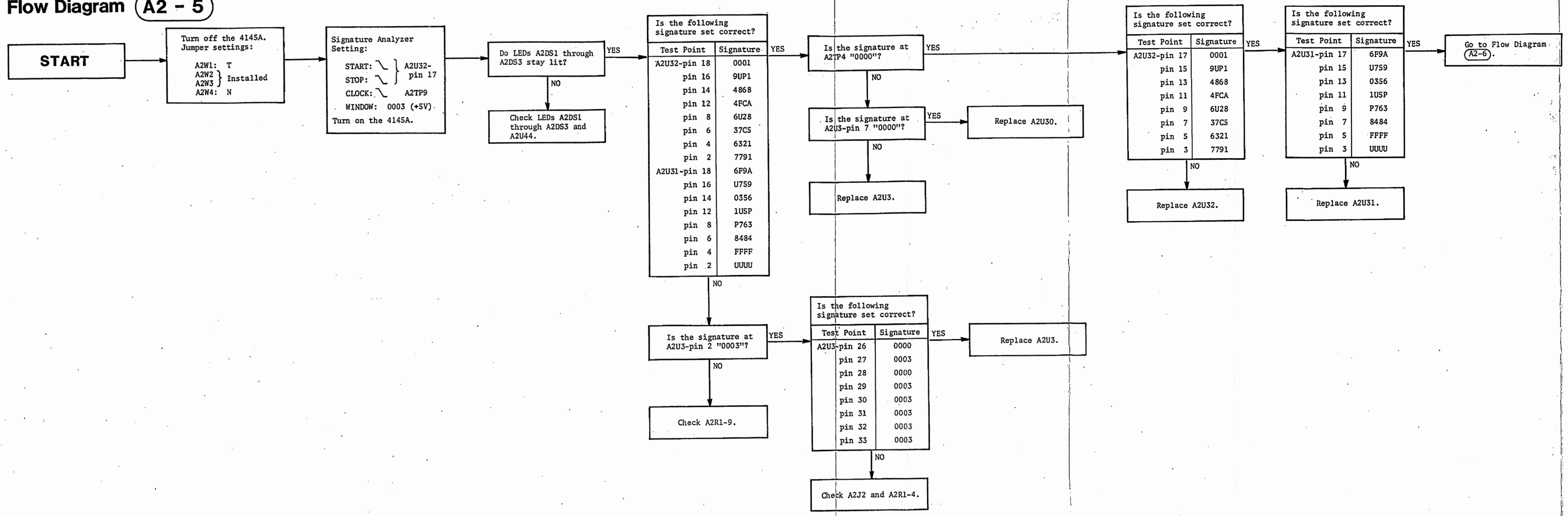
Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 1 of 12).

Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 2 of 12).

Flow Diagram (A2 - 4)



Flow Diagram A2 - 5



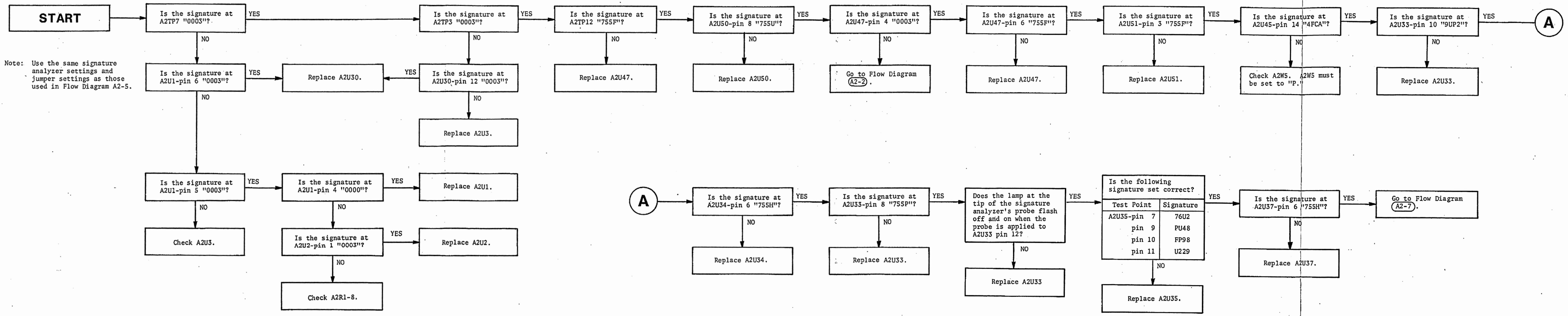
A2 SEE INSIDE

Troubleshooting Flow Diagram

Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 3 of 12).

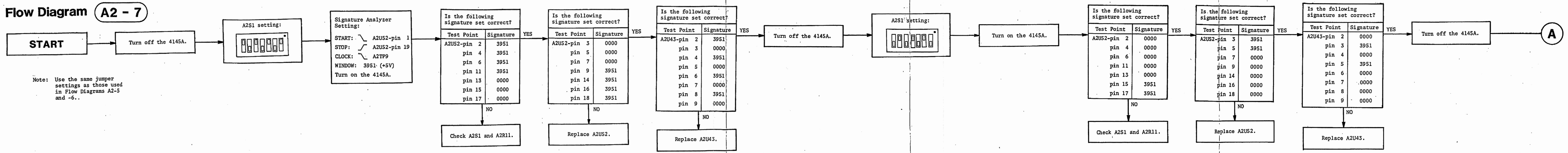
Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 4 of 12).

Flow Diagram A2 - 6



Note: Use the same signature analyzer settings and jumper settings as those used in Flow Diagram A2-5.

Flow Diagram (A2 - 7)



Note: Use the same jumper settings as those used in Flow Diagrams A2-5 and -6..

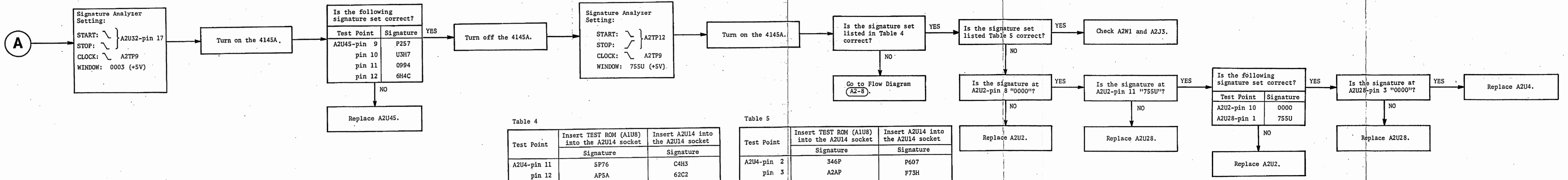


Table 4

Test Point	Insert TEST ROM (A1U8) into the A2U14 socket	Insert A2U14 into the A2U14 socket
	Signature	Signature
A2U4-pin 11	5P76	C4H3
pin 12	AP5A	62C2
pin 13	064P	8U32
pin 14	C09P	HPP4
pin 15	7H6A	91A4
pin 16	5871	5A4F
pin 17	A2AP	F73H
pin 18	346P	P607

Table 5

Test Point	Insert TEST ROM (A1U8) into the A2U14 socket	Insert A2U14 into the A2U14 socket
	Signature	Signature
A2U4-pin 2	346P	P607
pin 3	A2AP	F73H
pin 4	5871	5A4F
pin 5	7H6A	91A4
pin 6	C09P	HPP4
pin 7	064P	8U32
pin 8	AP5A	62C2
pin 9	5P76	C4H3

A2 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 5 of 12).

Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 6 of 12).

Flow Diagram (A2 - 8)

START

Turn off the 4145A.

Note: Use the same jumper settings as those used in Flow Diagrams A2-5, -6 and -7.

Signature Analyzer Setting:
START: ╲ A2U14-pin 18
STOP: ╱ A2U14-pin 20
CLOCK: ╲ A2TP9
WINDOW: P254 (+5V)
Turn on the 4145A.

Is the following signature set correct? *1

Test Point	Signature
A2U4-pin 11	P0P5
pin 12	9FH5
pin 13	4HCU
pin 14	95F5
pin 15	59FA
pin 16	9691
pin 17	A4C2
pin 18	UFF3

NO: Replace A2U14.

YES: Turn off the 4145A.

*1: TEST ROM (A1U8: P/N 04145-85028) must be inserted into the A2U14 socket.

Remove the TEST ROM (A1U8) from the A2U14 socket and reinstall A2U14. Turn on the 4145A.

Is the following signature set correct? *2

Test Point	Signature
A2U4-pin 11	07HC
pin 12	27CP
pin 13	270U
pin 14	6729
pin 15	97CH
pin 16	CP3A
pin 17	6FU5
pin 18	A6U0

NO: Replace A2U14.

YES: Turn off the 4145A. Remove A2U14, and insert the TEST ROM A1U8 into the A2U14 socket. *1

*2: Part number of A2U14 must be 04145-85034.

Signature Analyzer Setting:
START: ╲ A2U13-pin 18
STOP: ╱ A2U13-pin 20
CLOCK: ╲ A2TP9
WINDOW: P254 (+5V)
Turn on the 4145A.

Is the following signature set correct? *3

Test Point	Signature
A2U4-pin 11	9656
pin 12	68C6
pin 13	H031
pin 14	PPFA
pin 15	93C3
pin 16	458U
pin 17	F54F
pin 18	7U43

NO: Replace A2U13.

YES: Turn off the 4145A. → (A)

*3: Part number of A2U13 must be 04145-85023.

(A)

Signature Analyzer Setting:
START: ╲ A2U27-pin 18
STOP: ╱ A2U27-pin 20
CLOCK: ╲ A2TP9
WINDOW: P254 (+5V)
Turn on the 4145A.

Is the following signature set correct? *4

Test Point	Signature
A2U4-pin 11	P460
pin 12	H812
pin 13	6FAP
pin 14	93H9
pin 15	H947
pin 16	448H
pin 17	36C2
pin 18	1P57

NO: Replace A2U27.

YES: Turn off the 4145A.

*4: Part number of A2U27 must be 04145-85022

Signature Analyzer Setting:
START: ╲ A2U26-pin 18
STOP: ╱ A2U26-pin 20
CLOCK: ╲ A2TP9
WINDOW: P254 (+5V)
Turn on the 4145A.

Is the following signature set correct? *5

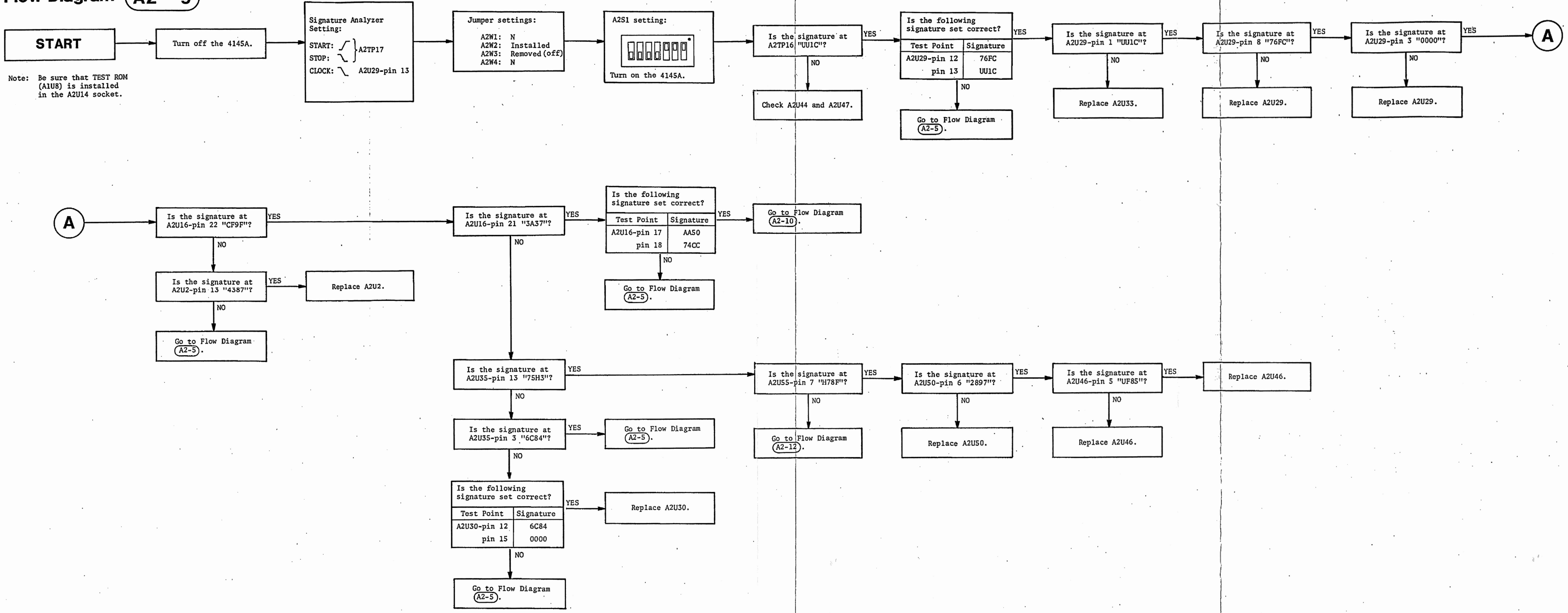
Test Point	Signature
A2U4-pin 11	06UA
pin 12	7H98
pin 13	P713
pin 14	6HU7
pin 15	PH6F
pin 16	18C3
pin 17	2351
pin 18	P4CA

NO: Replace A2U26.

YES: END (A2 MPU and ROMS are functioning properly.)

*5: Part number of A2U26 must be 04145-85021.

Flow Diagram (A2 - 9)

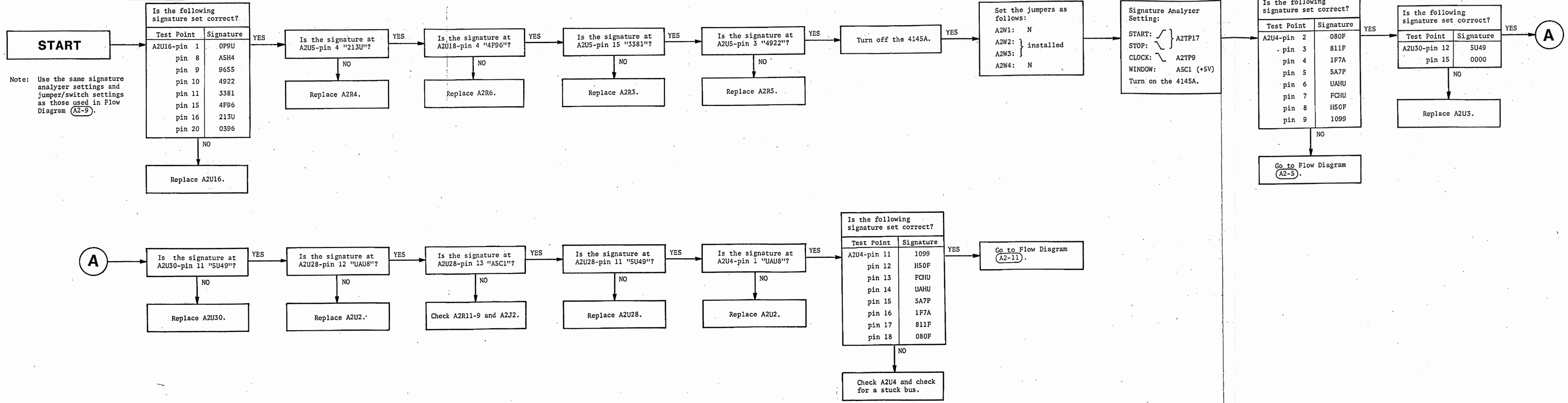


A2 Troubleshooting Flow Diagram

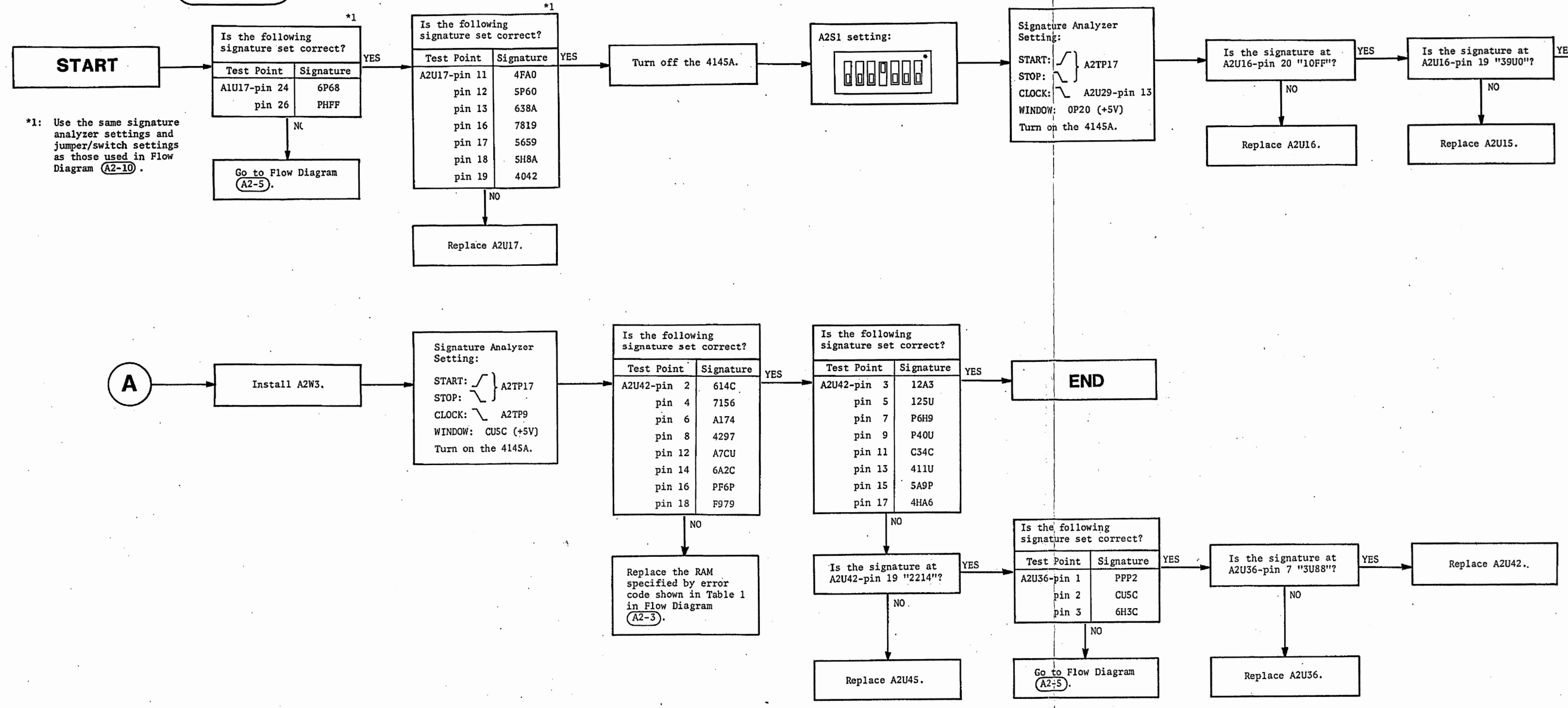
Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 7 of 12).

Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 8 of 12).

Flow Diagram (A2 - 10)



Flow Diagram (A2 - 11)



A2 Troubleshooting Flow Diagram
SEE INSIDE

Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 9 of 12).

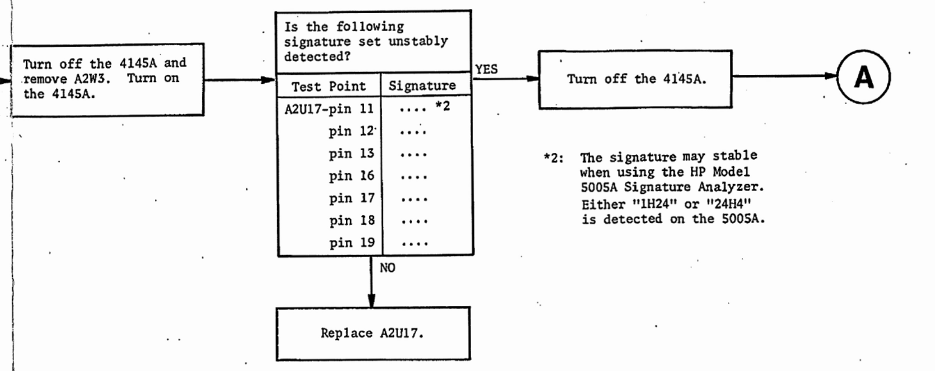
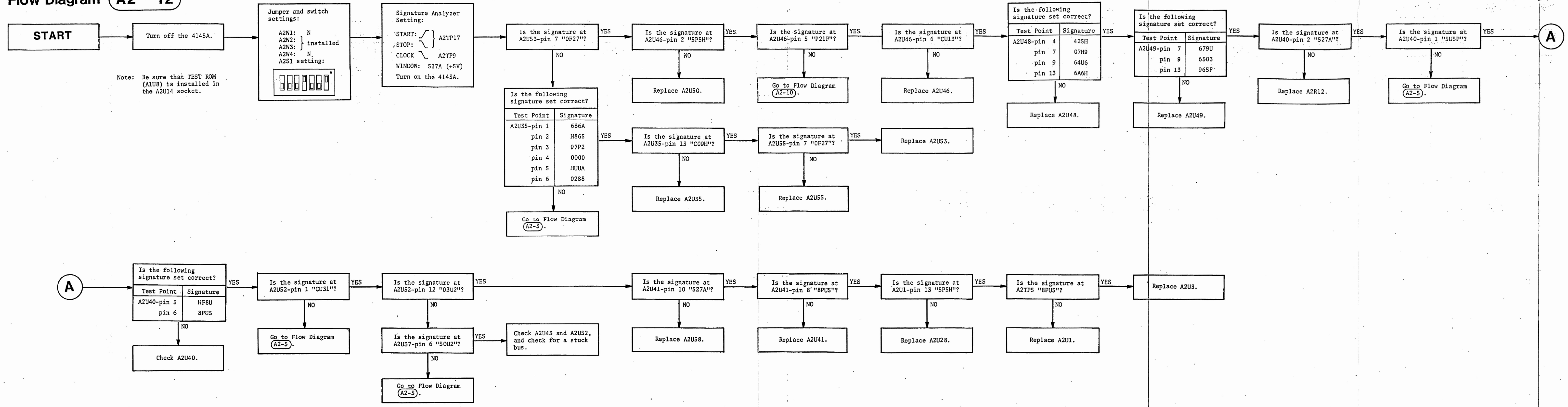
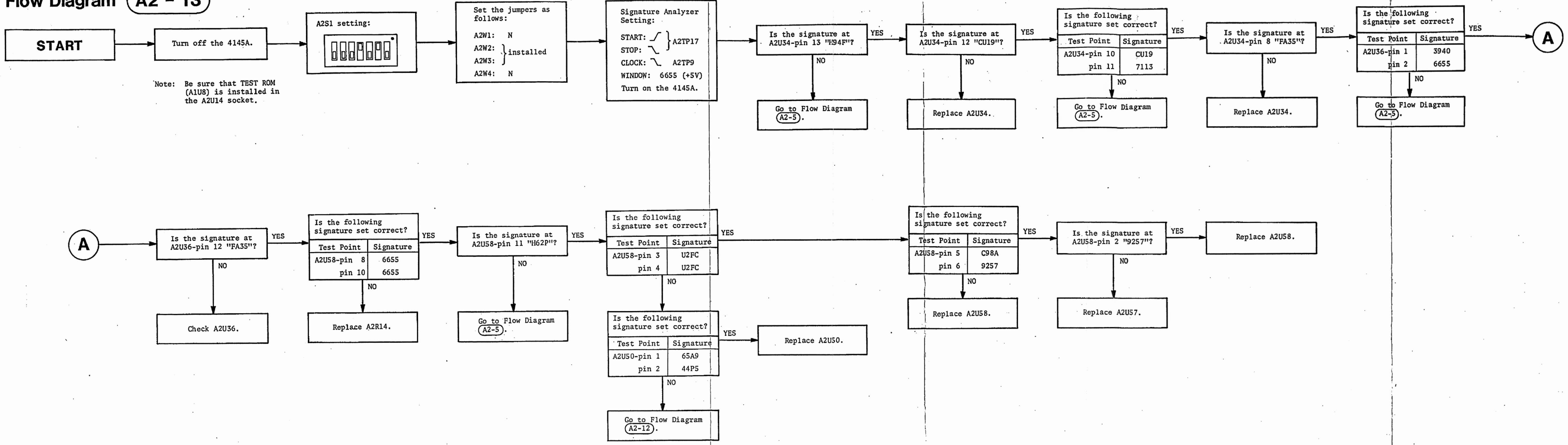


Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 10 of 12).

Flow Diagram (A2 - 12)



Flow Diagram (A2 - 13)



A2 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 11 of 12).

Figure 8-15. A2 Board Troubleshooting Flow Diagram (Sheet 12 of 12).

Flow Diagram A3 - 1

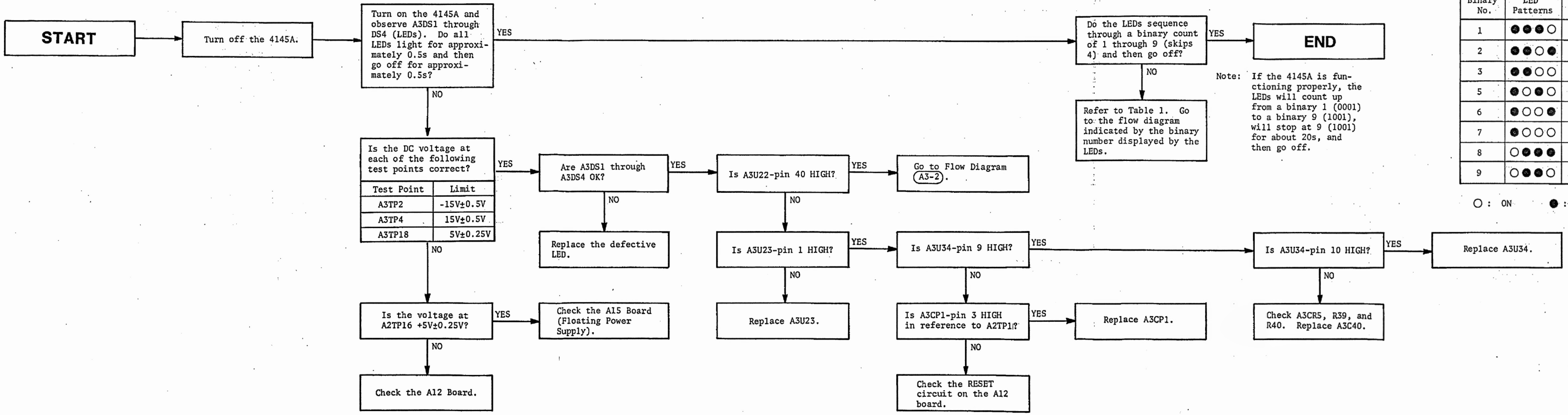
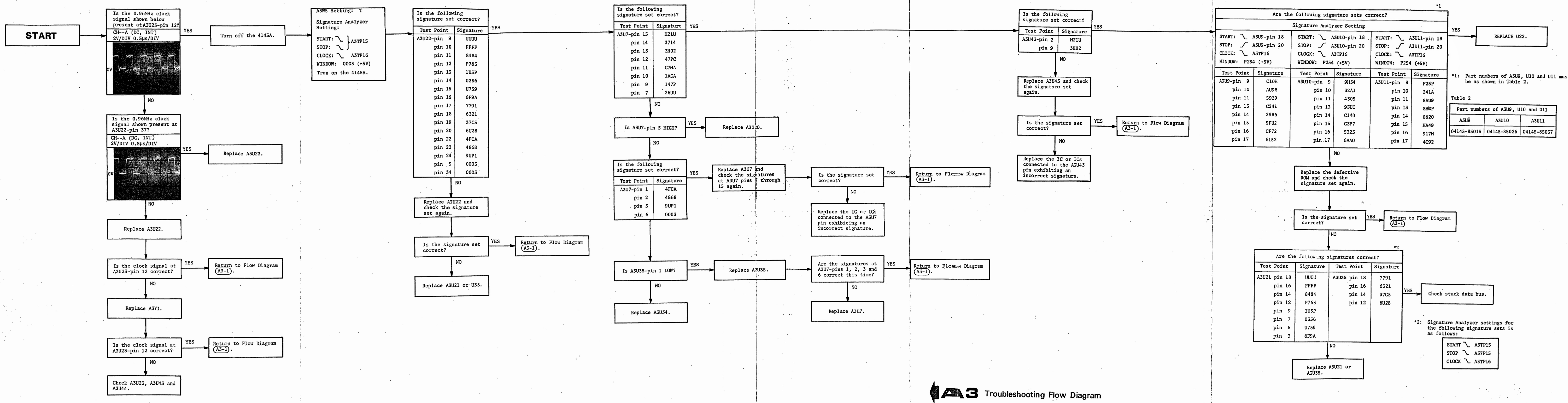


Table 1

Binary No.	LED Patterns	Flow Diagram to Go for Next
1	●●●○	Flow Diagram A3-3
2	●●○●	Flow Diagram A3-4
3	●●○○	Flow Diagram A3-5
5	●○●○	Flow Diagram A3-8
6	●○○●	Flow Diagram A4-1
7	●○○○	Flow Diagram A4-5
8	○●●●	Flow Diagram A4-6
9	○●●○	Flow Diagram A3-13

○ : ON ● : OFF

Flow Diagram (A3 - 2)



*1: Part numbers of A3U9, U10 and U11 must be as shown in Table 2.

Table 2

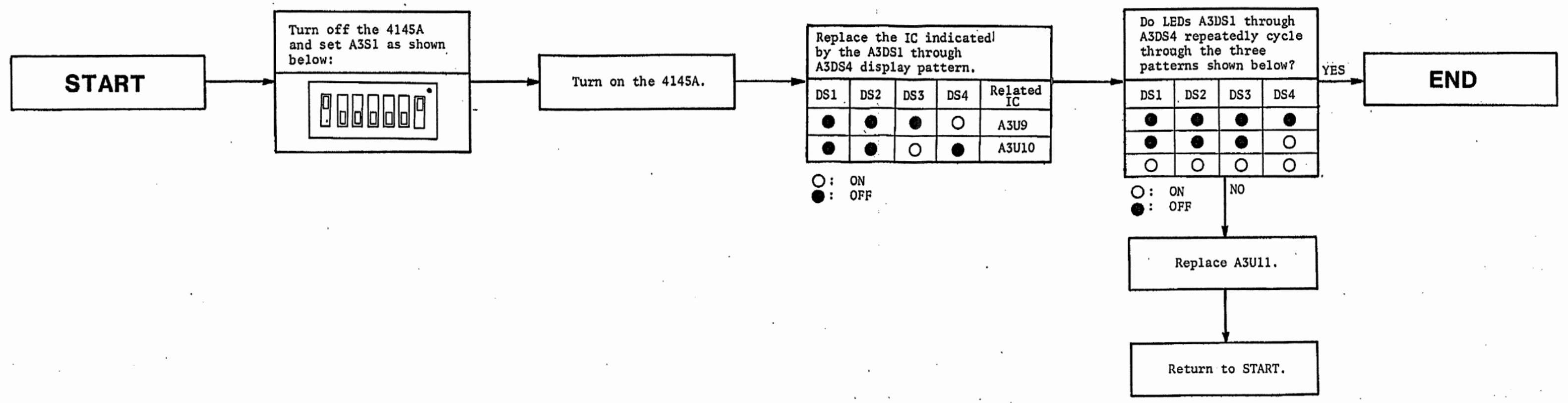
Part numbers of A3U9, U10 and U11		
A3U9	A3U10	A3U11
04145-85015	04145-85026	04145-85037

A3 Troubleshooting Flow Diagram

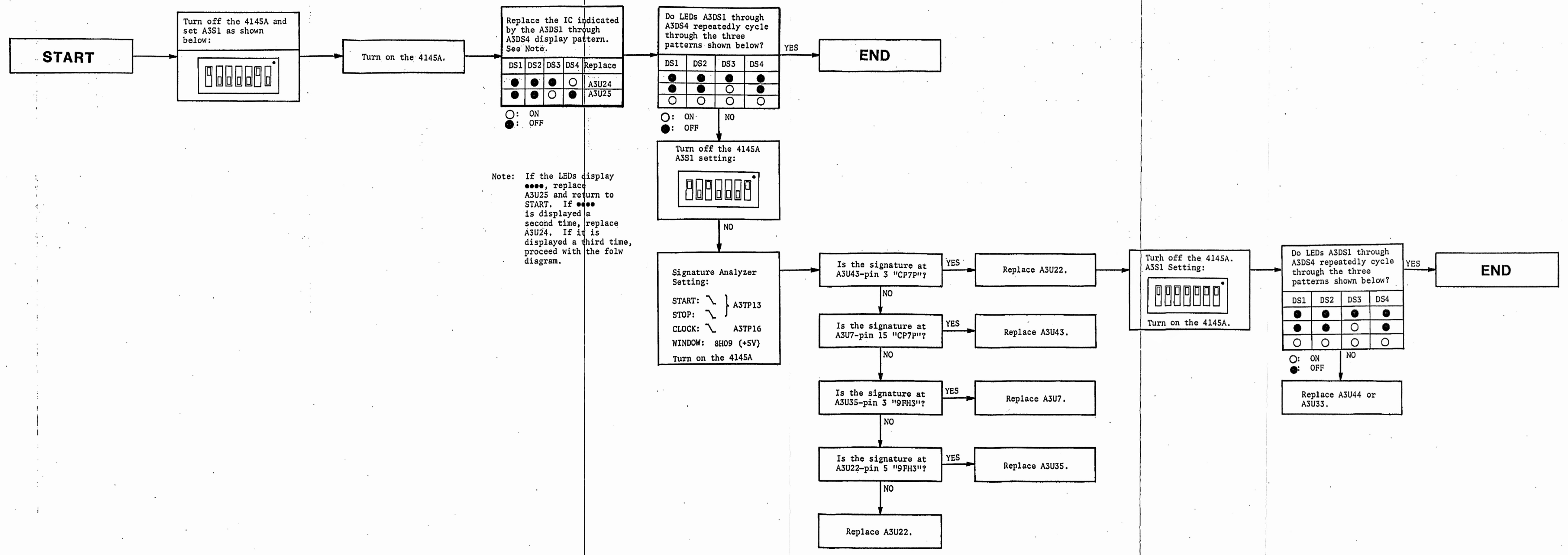
Figure 8-16. A3 Board Troubleshooting Flow Diagram (Sheet 1 of 9).

Figure 8-16. A3 Board Troubleshooting Flow Diagram (Sheet 2 of 9).

Flow Diagram (A3 - 3)



Flow Diagram (A3 - 4)



Flow Diagram (A3 - 5)

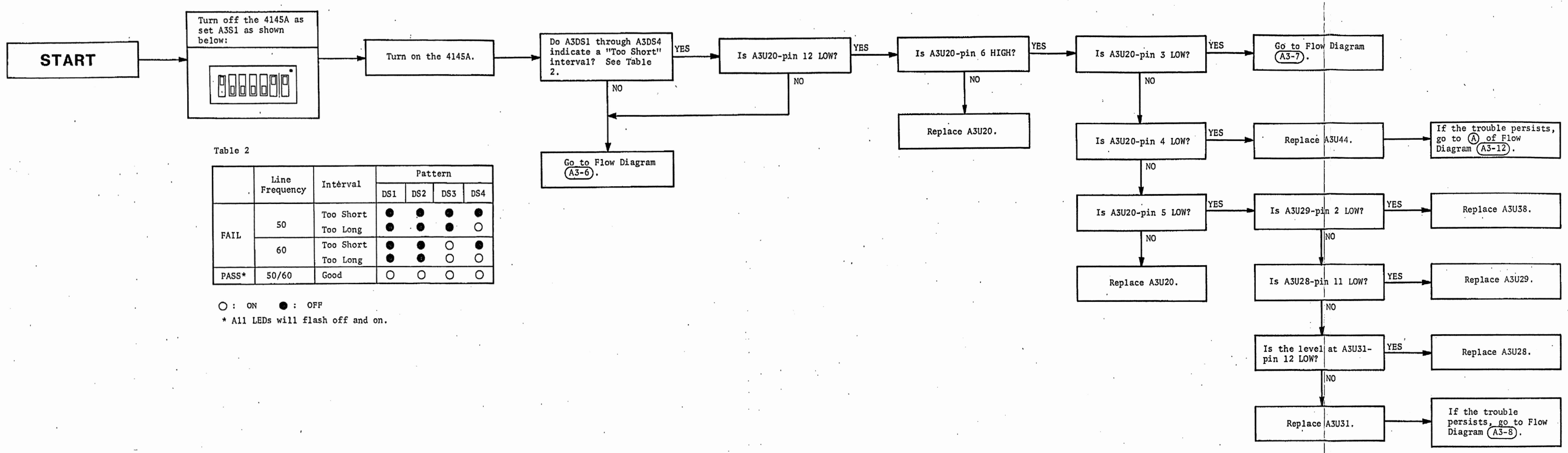


Table 2

	Line Frequency	Interval	Pattern			
			DS1	DS2	DS3	DS4
FAIL	50	Too Short	●	●	●	●
		Too Long	●	●	●	○
	60	Too Short	●	●	○	●
		Too Long	●	●	○	○
PASS*	50/60	Good	○	○	○	○

○ : ON ● : OFF

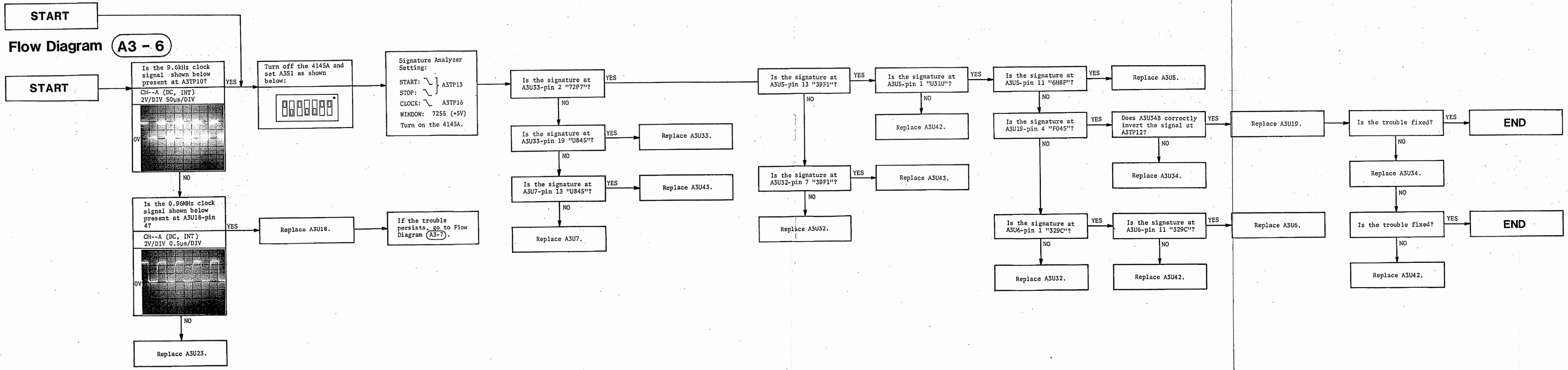
* All LEDs will flash off and on.

A3 Troubleshooting Flow Diagram

Figure 8-16. A3 Board Troubleshooting Flow Diagram (Sheet 3 of 9).

Figure 8-16. A3 Board Troubleshooting Flow Diagram (Sheet 4 of 9).

Flow Diagram (A3 - 7)



Flow Diagram (A3 - 8)

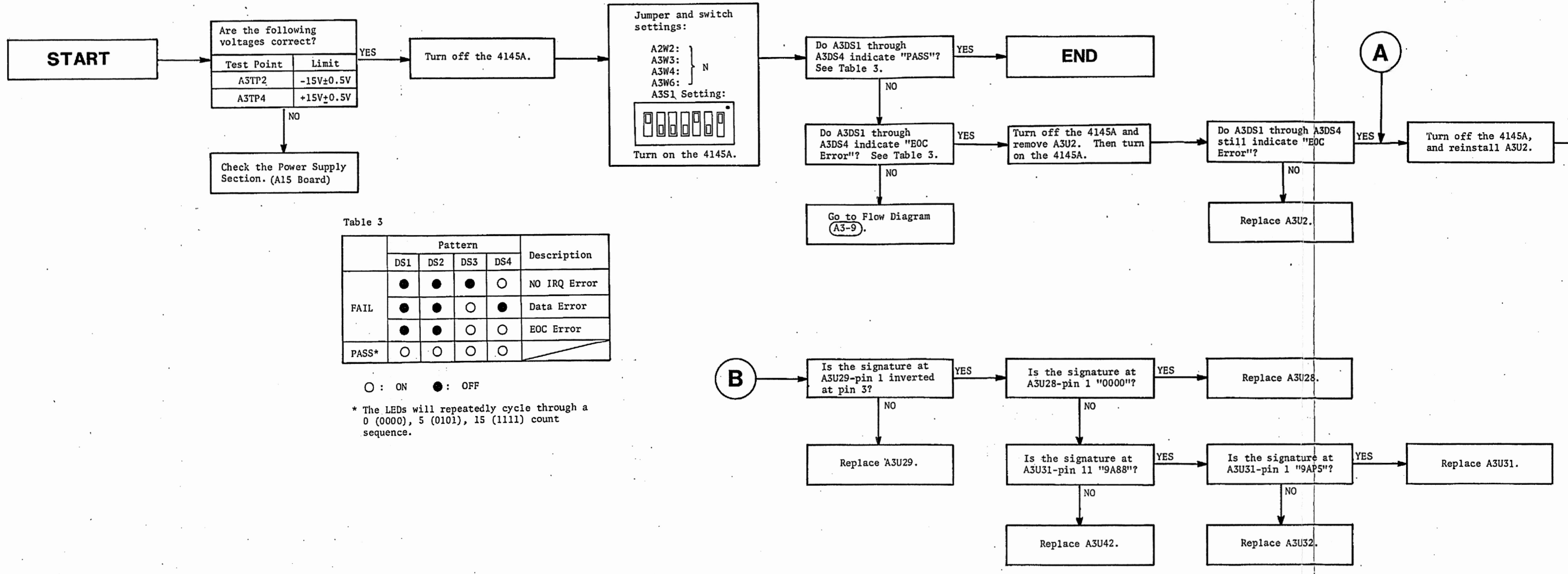


Table 3

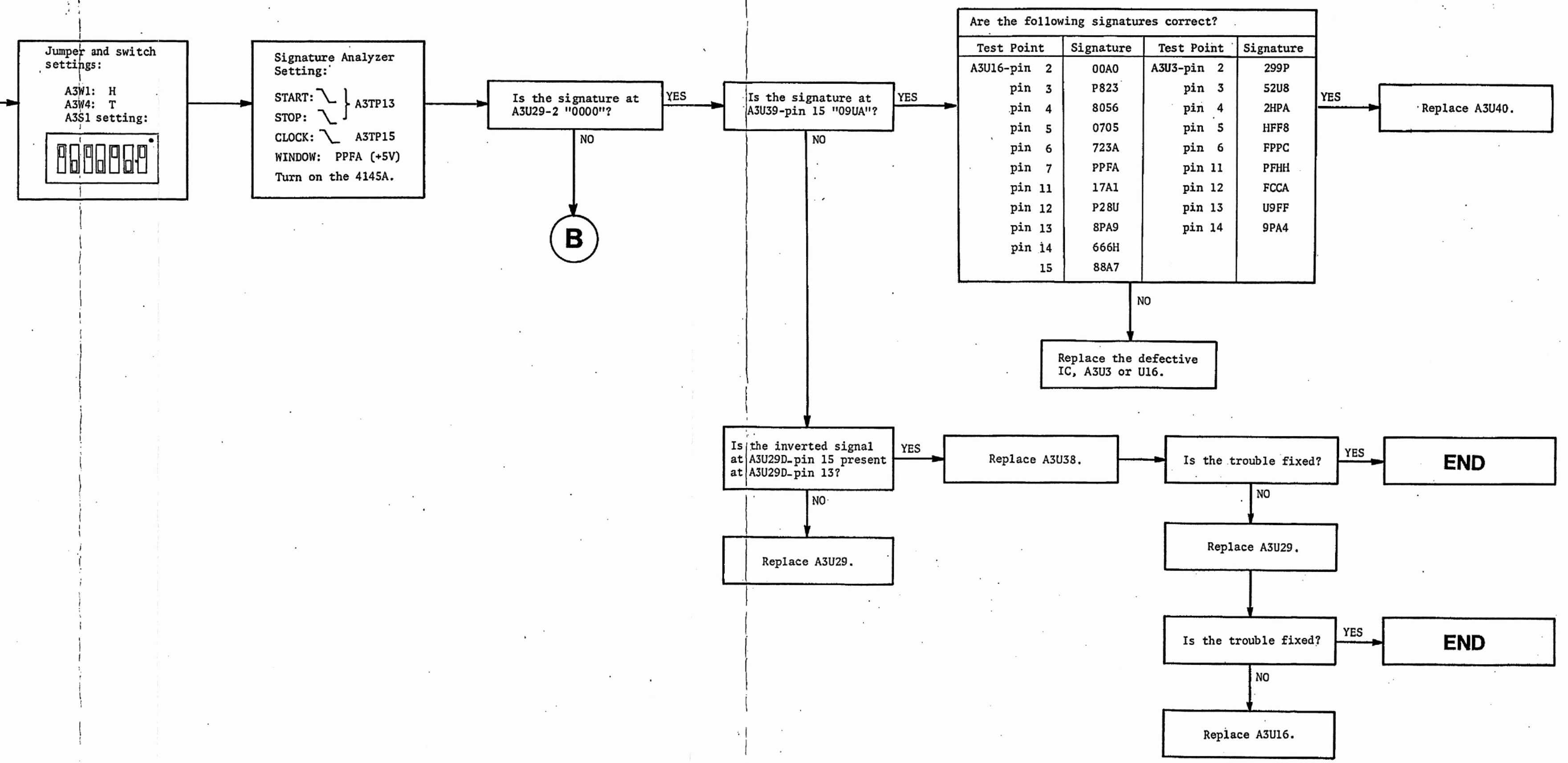
	Pattern				Description
	DS1	DS2	DS3	DS4	
FAIL	●	●	●	○	NO IRQ Error
	●	●	○	●	Data Error
	●	●	○	○	EOC Error
PASS*	○	○	○	○	

○ : ON ●: OFF

* The LEDs will repeatedly cycle through a 0 (0000), 5 (0101), 15 (1111) count sequence.

A3 Troubleshooting Flow Diagram

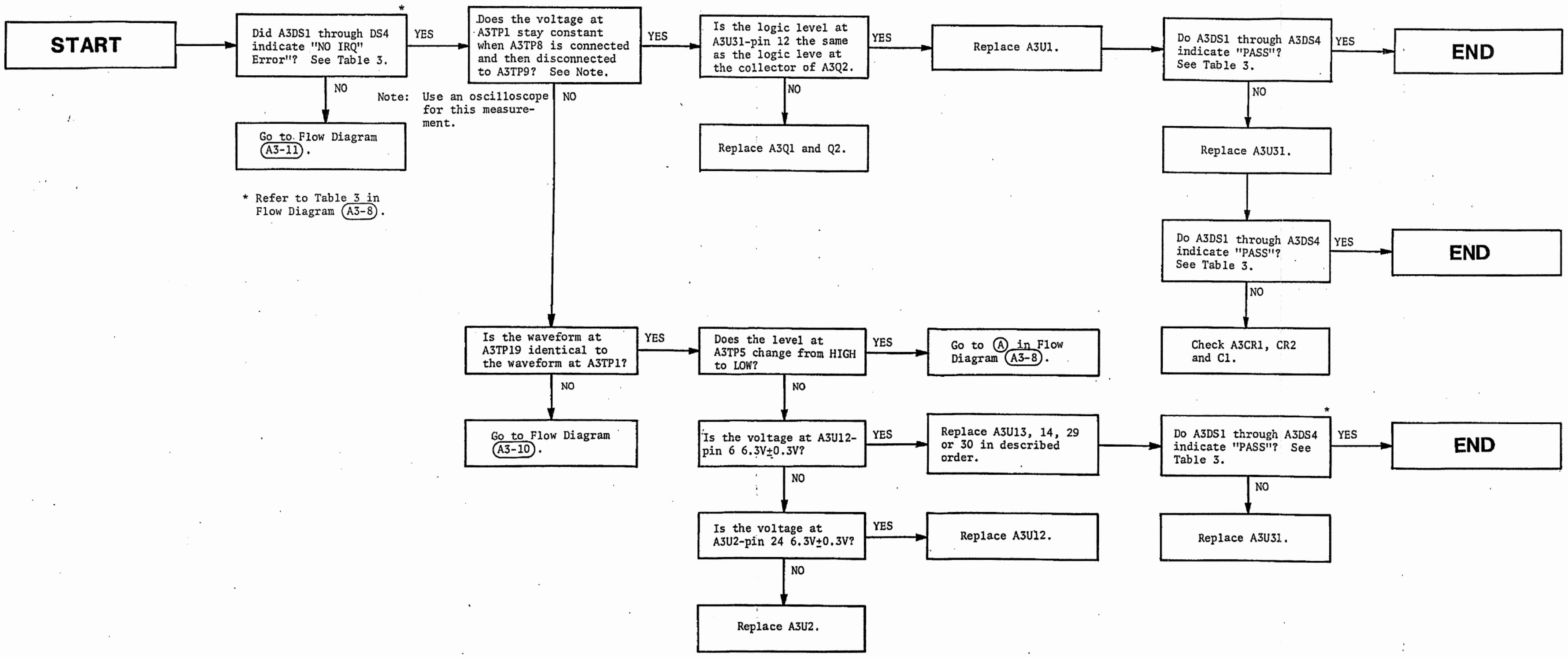
Figure 8-16. A3 Board Troubleshooting Flow Diagram (Sheet 5 of 9).



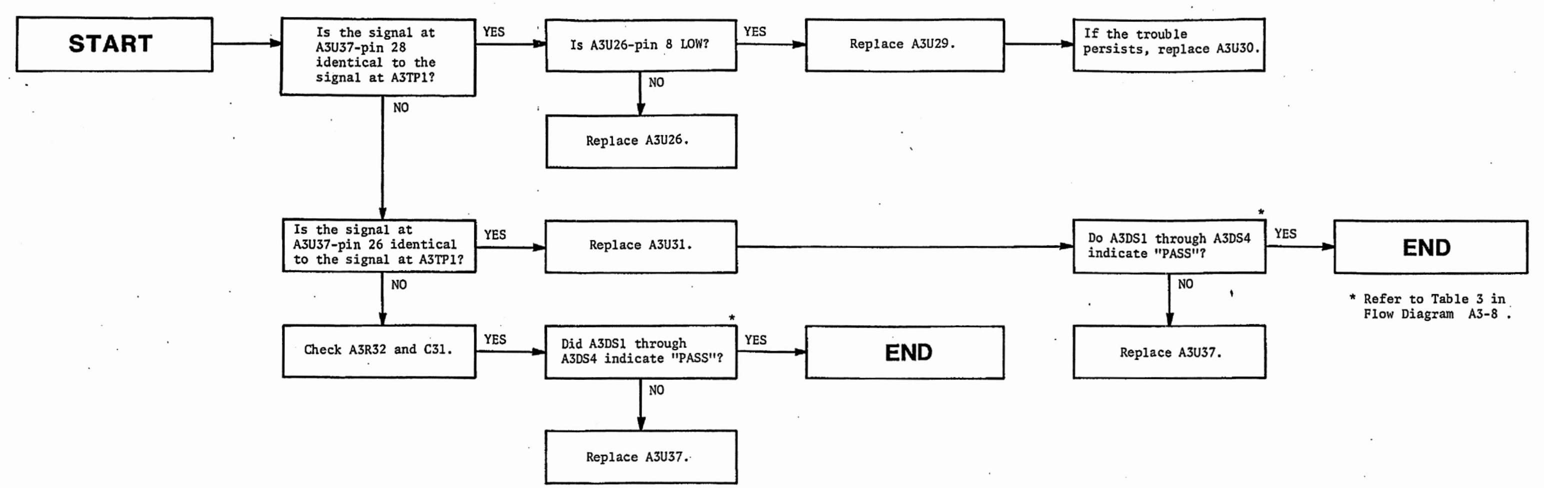
Test Point	Signature	Test Point	Signature
A3U16-pin 2	00A0	A3U3-pin 2	299P
pin 3	P823	pin 3	52U8
pin 4	8056	pin 4	2HPA
pin 5	0705	pin 5	HFF8
pin 6	723A	pin 6	FPPC
pin 7	PPFA	pin 11	PFHH
pin 11	17A1	pin 12	FCCA
pin 12	P28U	pin 13	U9FF
pin 13	8PA9	pin 14	9PA4
pin 14	666H		
15	88A7		

Figure 8-16. A3 Board Troubleshooting Flow Diagram (Sheet 6 of 9).

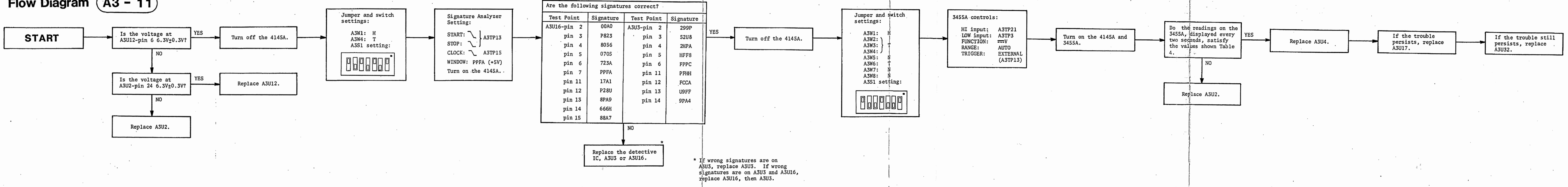
Flow Diagram (A3 - 9)



Flow Diagram (A3 - 10)



Flow Diagram (A3 - 11)



Are the following signatures correct?

Test Point	Signature	Test Point	Signature
A3U16-pin 2	00A0	A3U3-pin 2	299P
pin 3	P823	pin 3	52U8
pin 4	8056	pin 4	2HPA
pin 5	0705	pin 5	HFF8
pin 6	723A	pin 6	FPPC
pin 7	PPFA	pin 11	PFHH
pin 11	17A1	pin 12	FCCA
pin 12	P28U	pin 13	U9FF
pin 13	8PA9	pin 14	9PA4
pin 14	666H		
pin 15	88A7		

Table 4

No.	Reading on the 3455A
0	4096mV±15mV
1	2048mV±15mV
2	1024mV±15mV
3	512mV±15mV
4	256mV±15mV
5	128mV±15mV
6	64mV±15mV
7	32mV±15mV
8	16mV±15mV
9	8mV±15mV
10	4mV±15mV
11	2mV±15mV
12	1mV±15mV
13	0.5mV±15mV
14	0mV±15mV
15	0mV±15mV
16	0mV±15mV

A3 Troubleshooting Flow Diagram

Figure 8-16. A3 Board Troubleshooting Flow Diagram (Sheet 7 of 9).

Figure 8-16. A3 Board Troubleshooting Flow Diagram (Sheet 8 of 9).

Flow Diagram (A3 - 13)

START → Turn off the 4145A. → Jumper and switch settings:
A3W7: N
A3W8: T1(See Figure 1)
A3S1 setting:

→ Turn on the 4145A. → Are A3DS1 through A3DS4 lit?

YES → Go to Flow Diagram (A2-1).

NO → Turn off the 4145A, and set A3S1 as shown below. Turn on the 4145A. → (to Flow Diagram A3 - 12: Is the 250kHz clock signal shown below present at A3U44 pin 3?)

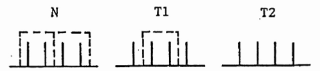
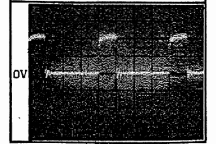


Figure 1.

Flow Diagram (A3 - 12)

START → Is the 250kHz clock signal shown below present at A3U44 pin 3?
CH--A (DC, INT)
2V/DIV 1µs/DIV.



YES → Turn off the 4145A. → Jumper and switch settings:
A3W8: T2
(See Figure 1.)
A3S1 setting:

→ Turn on the 4145A. → Do A3DS1 through A3DS4 indicate "PASS"? See Table 5.

YES → Check serial data at the EMITTER of A3Q5, A3CP3-pin 6, the EMITTER of A3Q4, and A3CP2-pin 6 in order described, referring the data from A3U44-pin 6.

NO → Do A3DS1 through A3DS4 indicate a "NO IRQ" Error? See Table 5.

YES → Turn off the 4145A. → Jumper and switch settings:
A3W7: T
A3W8: T1
(See Figure 1.)
A3S1 setting:

→ Signature Analyzer Settings:
START: ⌝ } A3TP13
STOP: ⌝
CLOCK: ⌝ A3TP16
WINDOW: F8PA (+5V)

→ Turn on the 4145A. → Is the signature at A3U44-pin 7 "213A"?

YES → Replace A3U20.

NO → Is the signature at A3U44-pin 9 "5P6H"?

NO (from "NO IRQ" Error?) → Turn off the 4145A. → Jumper and switch settings:
A3W7: T
A3W8: T1
(See Figure 1.)
A3S1 setting:

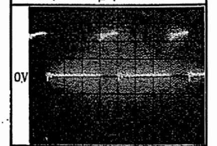
→ Signature Analyzer Settings:
START: ⌝ } A3TP13
STOP: ⌝
CLOCK: ⌝ A3TP16
WINDOW: F8PA (+5V)

→ Turn on the 4145A. → Is the signature at A3U44-pin 9 "5P6H"?

YES → Replace A3U44.

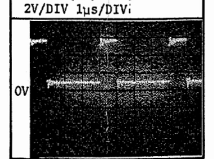
NO → Replace A3U7.

NO (from 250kHz clock signal) → Is the clock signal at the BASE of A3Q3 correct as shown below?
CH--A (DC, INT)
2V/DIV 1µs/DIV.



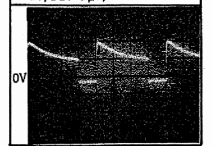
NO → Check ACIA and LOOP BACK TEST CIRCUIT on the A2 board.

YES → Is the clock signal at the EMITTER of A3Q3 correct as shown below?
CH--A (DC, INT)
2V/DIV 1µs/DIV.



NO → Replace A3Q3.

YES → Is the clock signal at A3T1-pin 8 correct as shown below?
CH--A (DC, INT)
2V/DIV 1µs/DIV.



YES → Replace A3U23.

NO → Replace A3CR6, then A3T1 (if necessary).

Table 5.

	Pattern				Description
	DS1	DS2	DS3	DS4	
PASS*	○	○	○	○	
FAIL	●	●	●	○	Data Error
	●	●	○	●	Flag Error
	●	○	●	●	No IRQ Error

○: ON ●: OFF

*. All LEDs flash off and on.

Page 8-52: blank

Flow Diagram A4 - 4

Flow Diagram A4 - 1

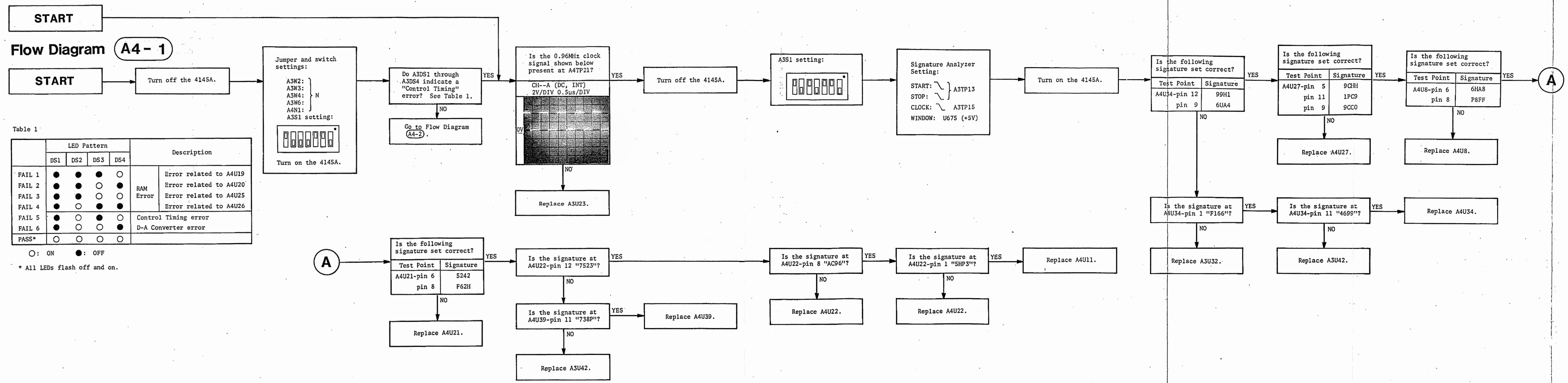


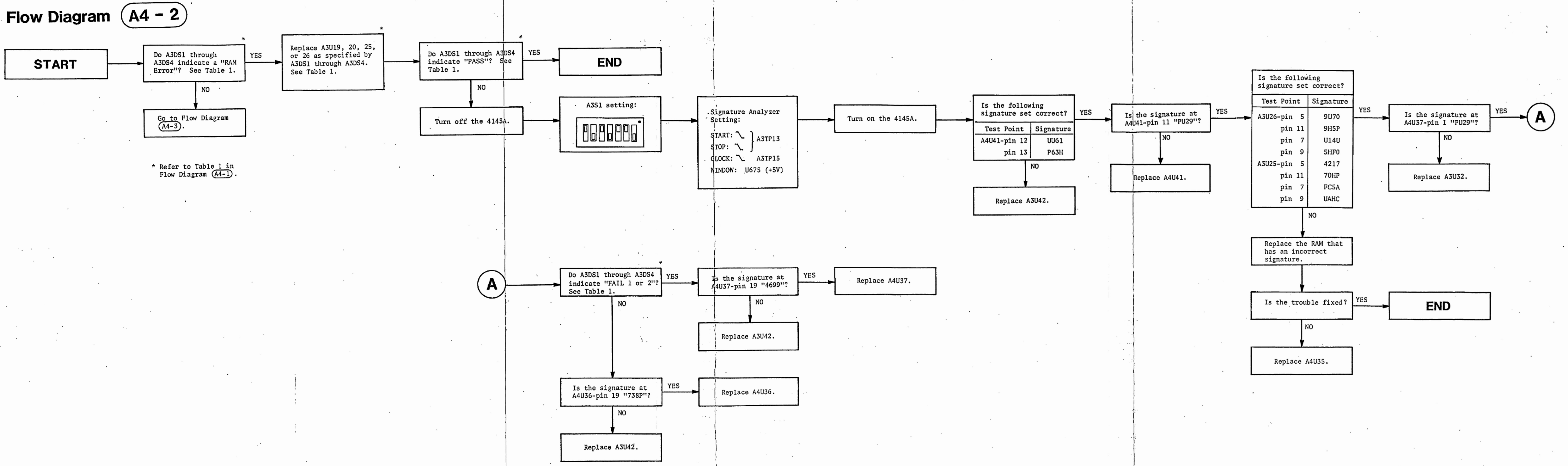
Table 1

	LED Pattern				Description	
	DS1	DS2	DS3	DS4		
FAIL 1	●	●	●	○	RAM Error	Error related to A4U19
FAIL 2	●	●	○	●		Error related to A4U20
FAIL 3	●	●	○	○		Error related to A4U25
FAIL 4	●	○	●	●		Error related to A4U26
FAIL 5	●	○	●	○	Control Timing error	
FAIL 6	●	○	○	●	D-A Converter error	
PASS*	○	○	○	○		

○: ON ●: OFF

* All LEDs flash off and on.

Flow Diagram (A4 - 2)



* Refer to Table 1 in Flow Diagram (A4-1).

A4 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-17. A4 Board Troubleshooting Flow Diagram (Sheet 1 of 5).

Figure 8-17. A4 Board Troubleshooting Flow Diagram (Sheet 2 of 5).

Flow Diagram (A4 - 3)

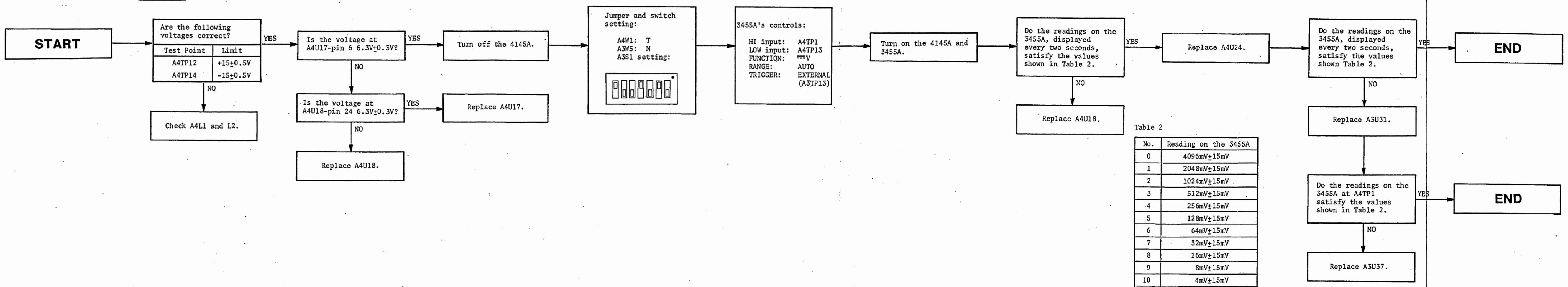
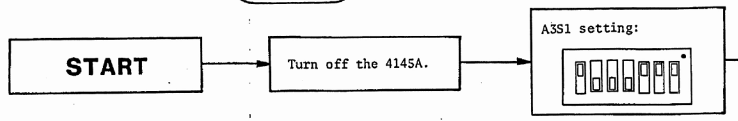
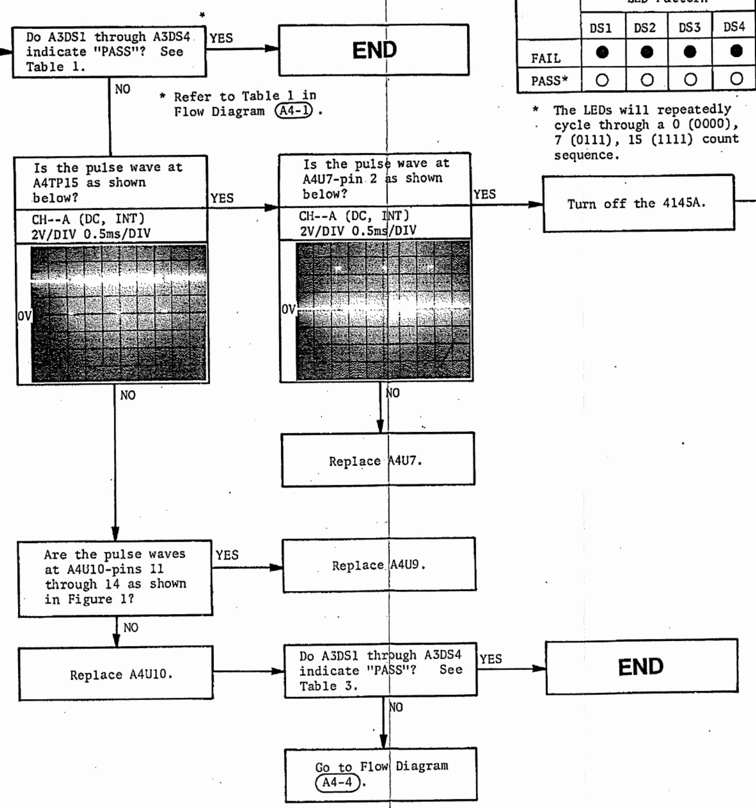


Table 2

No.	Reading on the 3455A
0	4096mV±15mV
1	2048mV±15mV
2	1024mV±15mV
3	512mV±15mV
4	256mV±15mV
5	128mV±15mV
6	64mV±15mV
7	32mV±15mV
8	16mV±15mV
9	8mV±15mV
10	4mV±15mV
11	2mV±15mV
12	1mV±15mV
13	0.5mV±15mV
14	0mV±15mV
15	0mV±15mV
16	0mV±15mV

Flow Diagram (A4 - 5)





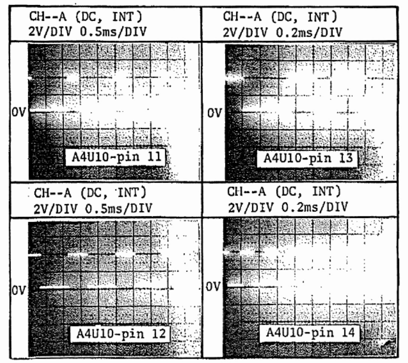
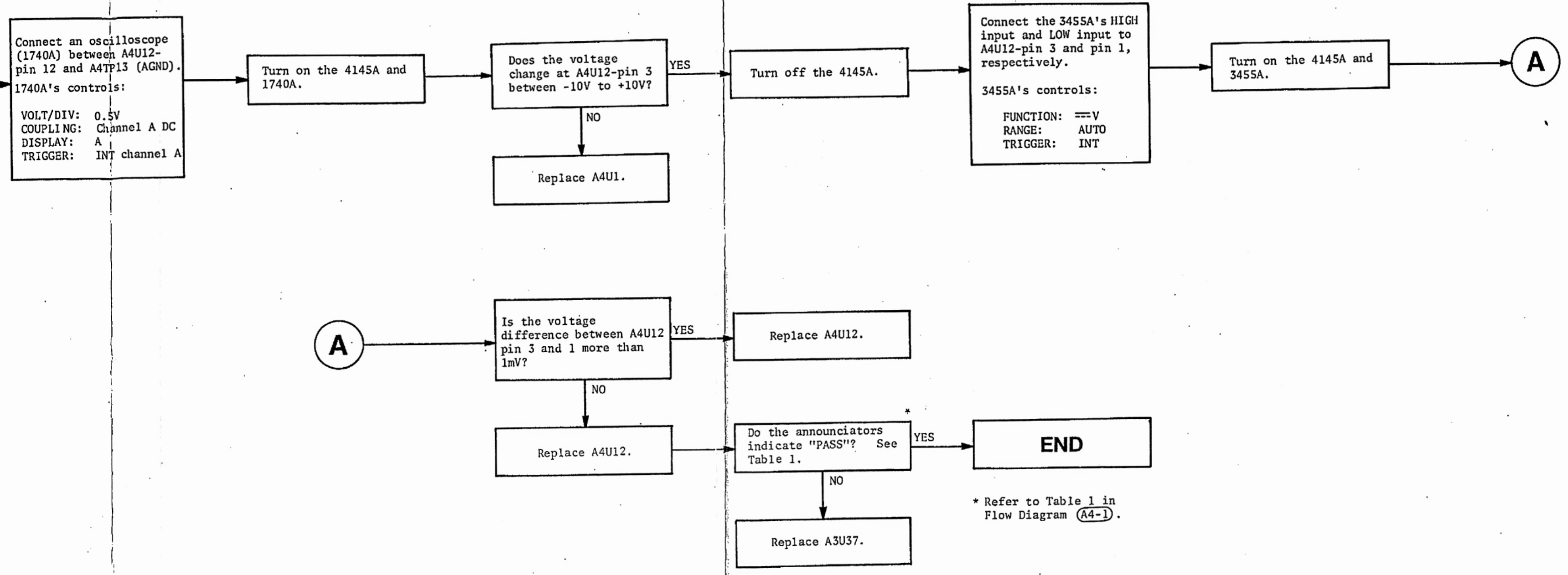


Figure 1.

Table 3

	LED Pattern			
	DS1	DS2	DS3	DS4
FAIL	●	●	●	●
PASS*	○	○	○	○

* The LEDs will repeatedly cycle through a 0 (0000), 7 (0111), 15 (1111) count sequence.



A4 Troubleshooting Flow Diagram

Figure 8-17. A4 Board Troubleshooting Flow Diagram (Sheet 3 of 5).

Figure 8-17. A4 Board Troubleshooting Flow Diagram (Sheet 4 of 5).

Flow Diagram (A4 - 6)

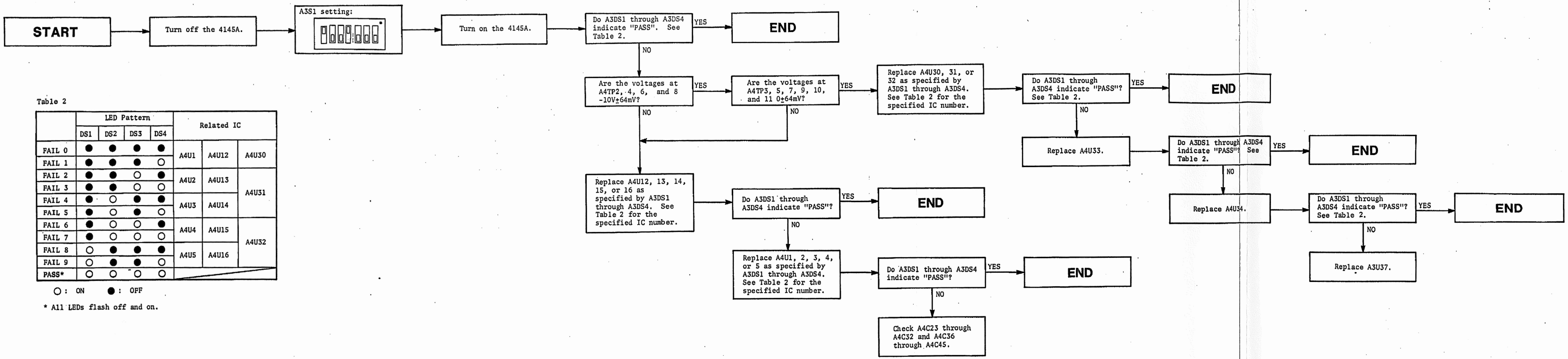


Table 2

	LED Pattern				Related IC		
	DS1	DS2	DS3	DS4			
FAIL 0	●	●	●	●	A4U1	A4U12	A4U30
FAIL 1	●	●	●	○			
FAIL 2	●	●	○	●	A4U2	A4U13	A4U31
FAIL 3	●	●	○	○			
FAIL 4	●	○	●	●	A4U3	A4U14	
FAIL 5	●	○	●	○			
FAIL 6	●	○	○	●	A4U4	A4U15	A4U32
FAIL 7	●	○	○	○			
FAIL 8	○	●	●	●	A4U5	A4U16	
FAIL 9	○	●	●	○			
PASS*	○	○	○	○			

○ : ON ● : OFF

* All LEDs flash off and on.

Page 8-58: blank

Flow Diagram (A9 - 1)

START

Turn on the 4145A.

Turn on the 4145A.
Are the following voltages correct?

Test Point	Limit
A9TP4	5V±0.25V
A9TP5	12V±1.2V

ON → Check the power supply section (A12 board).

YES → Turn off the 4145A.

Remove the FDD as described in paragraph 8-34. Connect the long flat cable (disconnected from the FDD) to the A17 board as shown Figure 1.

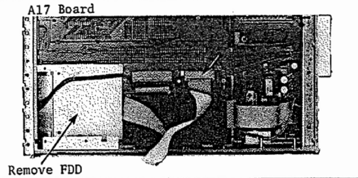


Figure 1.

Set the HP-IB Address Switch as shown below.

Jumper and switch settings:
A9W1:
A9W2:
A9W4:
A9W5: } T
A2S1 setting:

Turn on the 4145A.

Go to the Flow Diagram indicated by the A2DS1, DS2, and DS3 display pattern shown below:

Pattern	DS1	DS2	DS3	Flow Diagram
1	●	●	○	A9-6
2	●	○	●	A9-6
3	●	○	○	A9-11
PASS*1	○	○	○	See*1

○: ON
●: OFF

*1: If the LEDs repeatedly cycle through Patterns 1, 2, 3, and PASS, the MSU (Mass Storage Unit) is defective. Perform MSU Checks and Adjustments described starting in paragraph 5-30 on page 5-23.

Flow Diagram (A9 - 2)

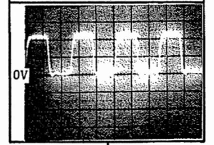
START

Are the following voltages correct?

Test Point	Limit
A9TP4	5V±0.25V
A9TP5	12V±1.2V

ON → Check the power supply section (A12 board).

YES → Is the clock signal at A9U7-pin 3 as shown below?
CH--Λ (DC, INT)
2V/DIV 0.1μs/DIV



NO → Check cable/connector and A2U51.

YES →
1) Turn off the 4145A.
2) Remove A1U8 and A2U14.
3) Insert A1U8 (TEST ROM) into the A2U14 socket.

Jumper and switch settings:
A2W1:
A2W4:
A2S1: } N
A2S1 setting:

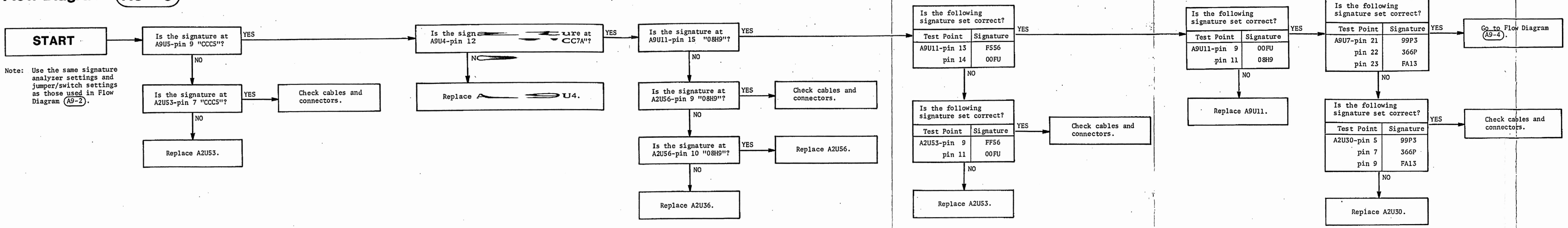
Signature Analyzer Setting:
START: } A2TP17
STOP:
CLOCK: A2TP9
WINDOW: 00FU (+5V)

Turn on the 4145A.

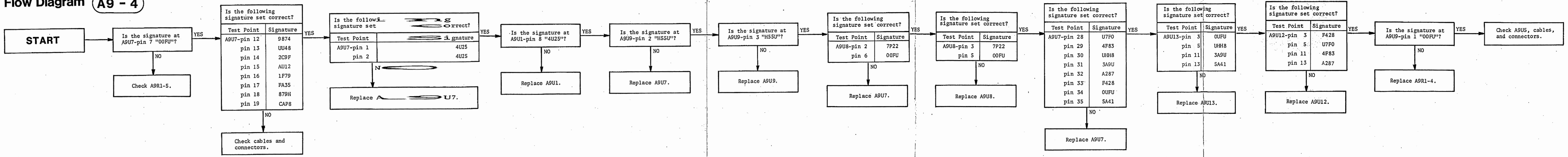
Does the 4145A pass the HP-IB Interface Test (steps 1 through 7 on pages 4-27 and -28)?
YES → Go to Flow Diagram (A9-3).
NO → Is the signature at A9U19-pin 1 "30HA"?
YES → Go to Flow Diagram (A9-5).
NO → Is the signature at A9U4-pin 1 "FA13"?
NO → Is the signature at A2U30-pin 9 "FA13"?
YES → Check cables and connectors.
NO → Replace A2U30.

(From A9U4-pin 1 "FA13": YES →) Is the signature A9U4-pin 2 "FAHF"?
NO → Replace A9U4.
YES → Is the signature at A9U6-pin 5 "30HA"?
YES → Replace A9U6.
NO → Is the signature at A2U56-pin 11 "30HA"?
YES → Check cables and connectors.
NO → Replace A2U36.

Flow Diagram (A9 - 3)



Flow Diagram (A9 - 4)



A9 Troubleshooting Flow Diagram

Figure 8-18. A9 Board Troubleshooting Flow Diagram (Sheet 1 of 6).

Figure 8-18. A9 Board Troubleshooting Flow Diagram (Sheet 2 of 6).

Flow Diagram (A9-5)

START

Note: Use the same signature analyzer settings and jumper/switch settings as those used in Flow Diagram (A9-2).

Turn off the 4145A.

Signature Analyzer Setting:
START: ╲ A9U19-pin 1
STOP: ╱ A9U19-pin 19
CLOCK: ╲ A9U11-pin 14
WINDOW: 0001 (+5V)

Turn on the 4145A.

Is the signature at A9U4-pin 1 "0001"? NO: Replace A2U30. YES:

Is the signature at A9U4-pin 2 "0000"? NO: Replace A9U4. YES:

Is the signature at A9U6-pin 6 "0000"? NO: Replace A9U6. YES:

Turn off the 4145A.

HP-IB Address (on the rear panel) setting:

Turn on the 4145A.

Is the following signature set correct?

Test Point	Signature
A9U19-pin 2	0001
pin 4	0001
pin 6	0001
pin 11	0000
pin 13	0001
pin 15	0000
pin 17	0000

NO: Check HP-IB Address Switch, cables, and connectors. YES:

Is the following signature set correct?

Test Point	Signature
A9U19-pin 3	0000
pin 5	0000
pin 7	0001
pin 9	0000
pin 14	0001
pin 16	0001
pin 18	0001

NO: Replace A9U19. YES: (A)

(A) Turn off the 4145A.

HP-IB Address (on the rear panel) setting:

Turn on the 4145A.

Is the following signature set correct?

Test Point	Signature
A9U19-pin 2	0000
pin 4	0000
pin 6	0000
pin 11	0001
pin 13	0000
pin 15	0001
pin 17	0001

NO: Check HP-IB Address Switch, cable and connectors. YES:

Is the following signature set correct?

Test Point	Signature
A9U19-pin 3	0001
pin 5	0001
pin 7	0000
pin 9	0001
pin 14	0000
pin 16	0000
pin 18	0000

NO: Replace A9U19. YES:

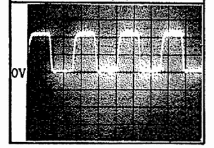
Check HP-IB Address Switch, cables, and connectors between the A9 board and Mother board.

Flow Diagram (A9-6)

START

Turn on the 4145A.

Is the clock signal at A9U7-pin 3 as shown below?
CH--A (DC, INT)
2V/DIV 0.1μs/DIV


0V

1) Turn off the 4145A.
2) Remove A1U8 and A2U14.
3) Insert A1U8 (TEST ROM) into the A2U14 socket.

Jumper and switch Setting:
A2W1: } N
A2W4: }
A2S1 setting:

Signature Analyzer Setting:
START: ╲ } A2TP17
STOP: ╱ }
CLOCK: ╲ A2TP9
WINDOW: P5P5 (+5V)
Turn on the 4145A.

Did A2DS1, DS2, and DS3 indicate Pattern 2 (●○●) in Flow Diagram (A9-1)? YES: Go to Flow Diagram (A9-10). NO: (B)

(B) Is the signature at A9U5-pin 10 "278U"? YES: see below. NO:

Is the signature at A2U56-pin 3 "278U"? YES: Check cables and connectors. NO:

Is the signature at A2U56-pin 2 "278U"? YES: Replace A2U56. NO: Replace A2U55.

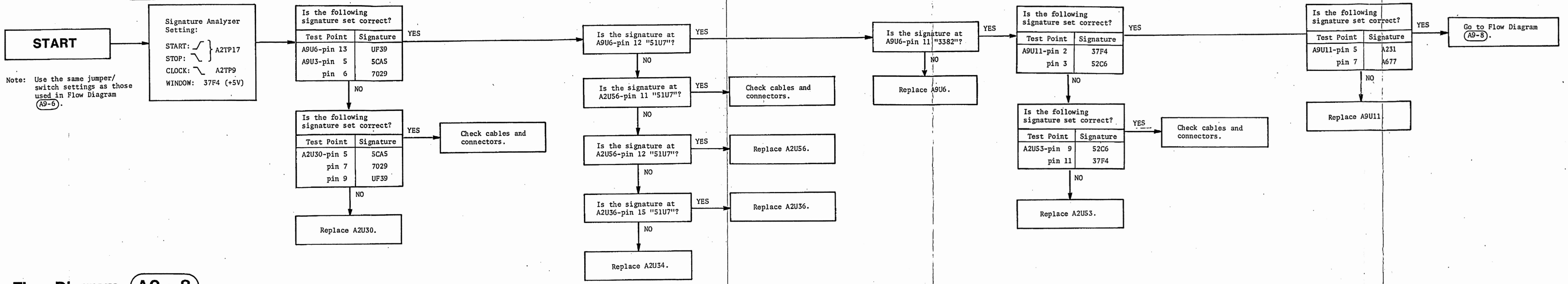
(A9U5-pin 10 YES) Is the signature at A9U5-pin 9 "HC92"? NO:

Is the signature at A9U53-pin 7 "HC92"? YES: Check cables and connectors. NO: Replace A2U53.

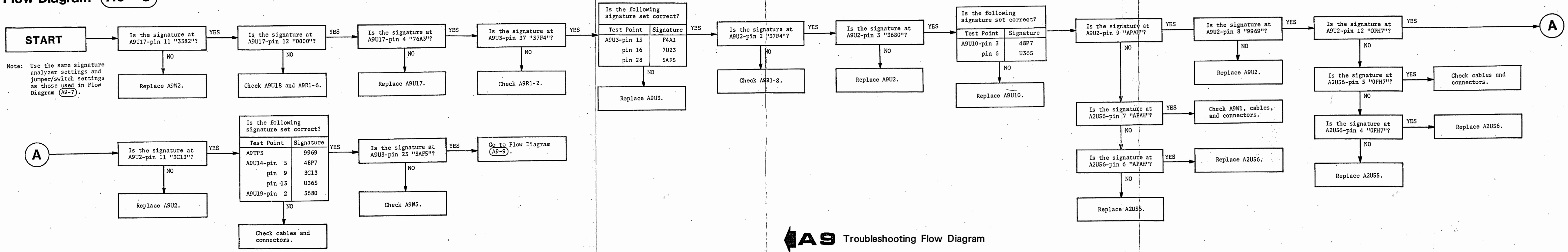
(A9U5-pin 9 YES) Is the signature at A9U5-pin 8 "UF1H"? NO: Replace A9U5. YES:

Is the signature at A9U3-pin 19 "19U8"? NO: Replace A9U4. YES: Go to Flow Diagram (A9-7).

Flow Diagram (A9 - 7)



Flow Diagram (A9 - 8)

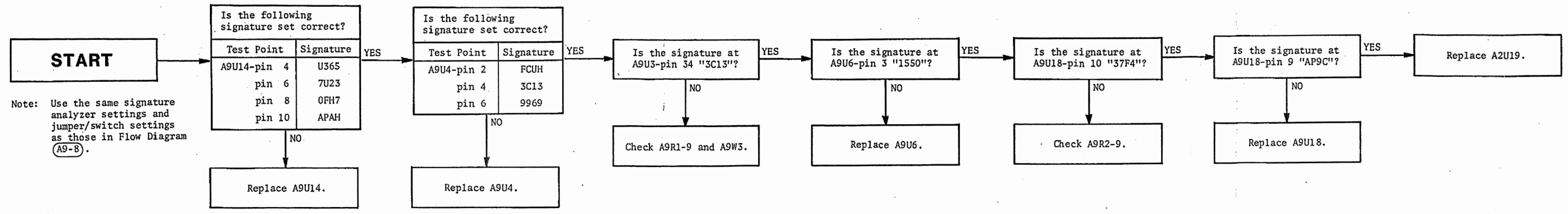


A9 Troubleshooting Flow Diagram
SEE INSIDE

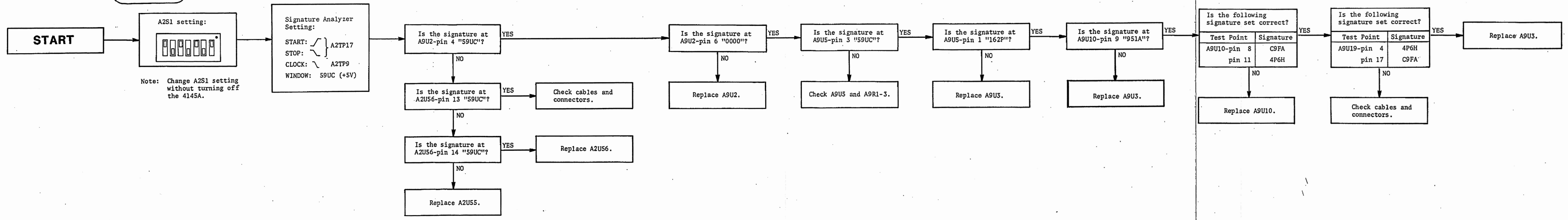
Figure 8-18. A9 Board Troubleshooting Flow Diagram (Sheet 3 of 6).

Figure 8-18. A9 Board Troubleshooting Flow Diagram (Sheet 4 of 6).

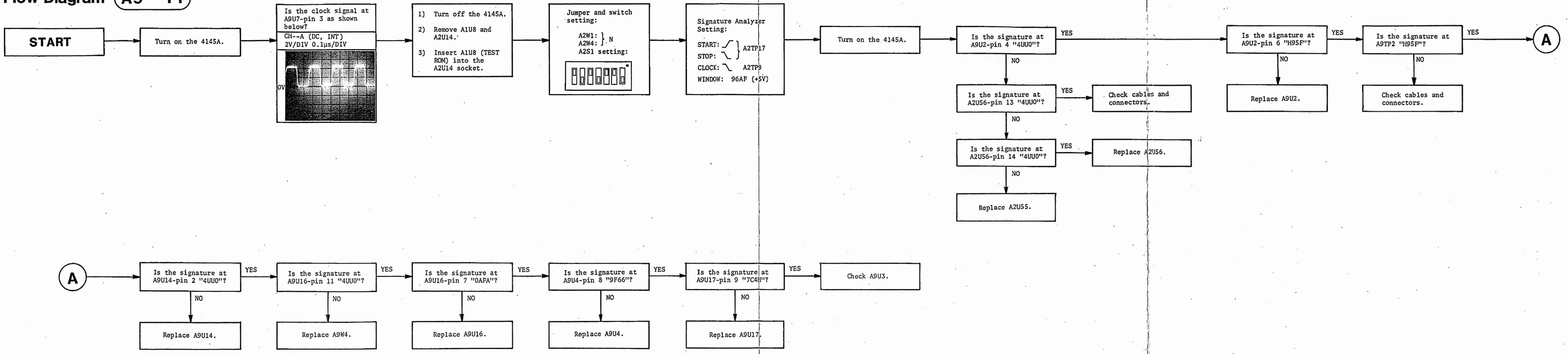
Flow Diagram (A9 - 9)



Flow Diagram (A9 - 10)



Flow Diagram (A9 - 11)

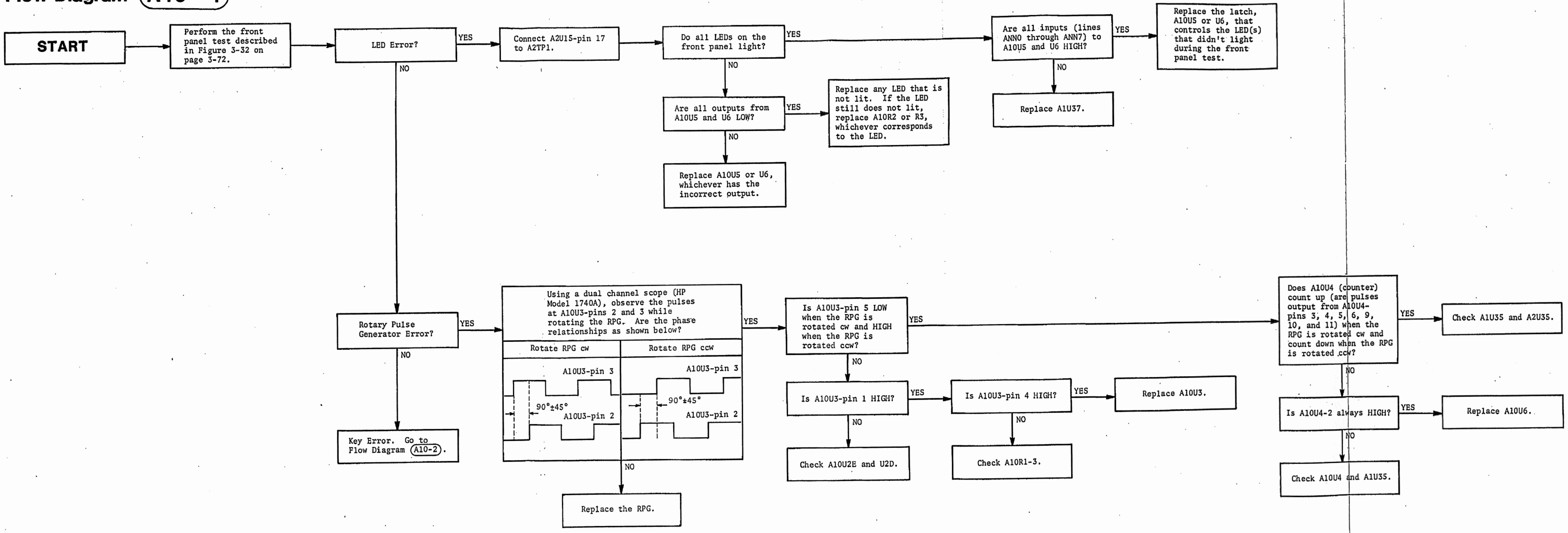


A9 Troubleshooting Flow Diagram
SEE INSIDE

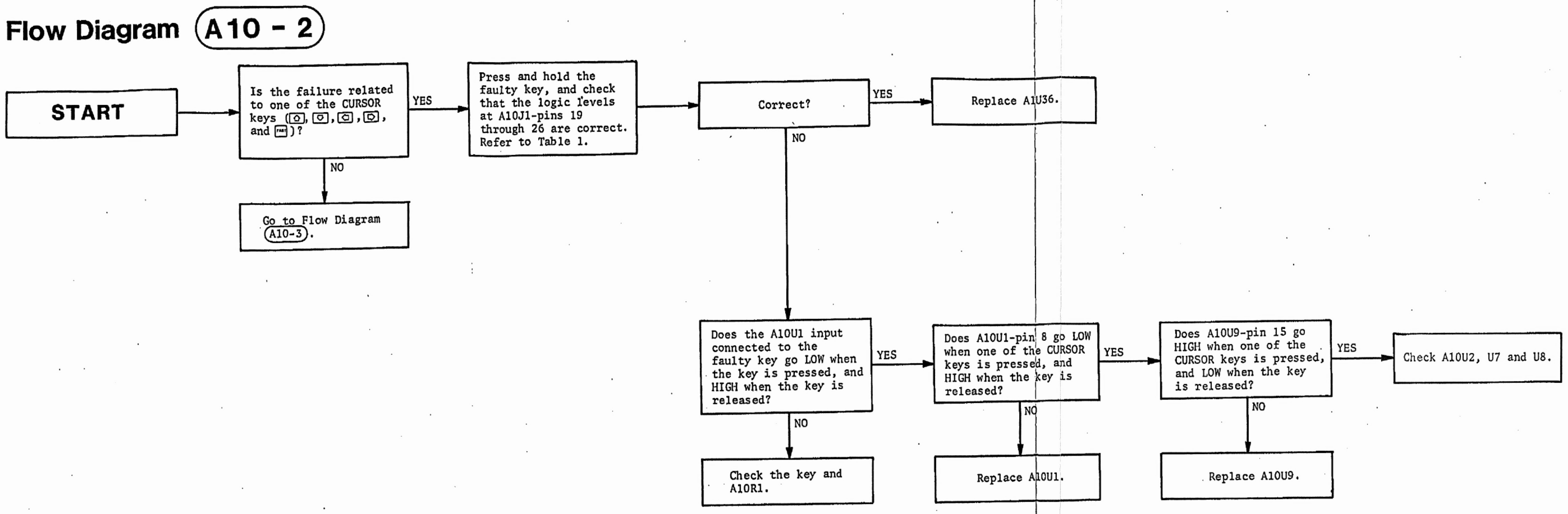
Figure 8-18. A9 Board Troubleshooting Flow Diagram (Sheet 5 of 6).

Figure 8-18. A9 Board Troubleshooting Flow Diagram (Sheet 6 of 6).

Flow Diagram (A10 - 1)



Flow Diagram (A10 - 2)



A10 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-19. A10 Board Troubleshooting Flow Diagram (Sheet 1 of 3).

Table 1

Key Name	26	25	24	23	22	21	20	19
A10U10 pins	–	–	–	–	–	8	4	5
EXTN	0	0	0	0	0	0	0	0
SOFT KEY 1	0	0	0	0	0	0	0	1
SOFT KEY 2	0	0	0	0	0	0	1	0
SOFT KEY 3	0	0	0	0	0	0	1	1
SOFT KEY 4	0	0	0	0	0	1	0	0
SOFT KEY 5	0	0	0	0	0	1	0	1
SOFT KEY 6	0	0	0	0	0	1	1	0
SOFT KEY 7	0	0	0	0	0	1	1	1
MENU	0	0	0	0	1	0	0	0
PREV	0	0	0	0	1	0	0	1
NEXT	0	0	0	0	1	0	1	0
BACK	0	0	0	0	1	1	0	0
DELETE	0	0	0	0	1	1	0	1
RCL	0	0	0	0	1	1	1	0
SAVE	0	0	0	0	1	1	1	1
SINGLE	0	0	0	1	0	0	0	0
APPEND	0	0	0	0	0	0	0	1
FORWARD	0	0	0	0	0	1	0	0
INSERT	0	0	0	0	0	1	0	1
CLEAR	0	0	0	0	0	1	1	0
GET	0	0	0	0	0	1	1	1
REPEAT	0	0	0	0	1	0	0	0
STOP	0	0	0	0	1	0	0	1
AUTO CAL	0	0	0	0	1	0	1	0
(	0	0	0	0	1	0	1	1
7	0	0	0	0	1	1	0	0
4	0	0	0	0	1	1	0	1
1	0	0	0	0	1	1	1	0
ϕ	0	0	0	0	1	1	1	1

Key Name	26	25	24	23	22	21	20	19
A10U10 pins	–	–	–	–	–	8	4	5
START/STOP	0	0	1	0	0	0	0	0
CONT	0	0	0	0	0	0	0	1
PRINT	0	0	0	0	0	0	1	0
)	0	0	0	0	0	0	1	1
8	0	0	0	0	0	1	0	0
5	0	0	0	0	0	1	0	1
2	0	0	0	0	0	1	1	0
●	0	0	0	0	0	1	1	1
SHORT	0	0	0	0	1	0	0	0
MED	0	0	0	0	1	0	0	1
LONG	0	0	0	0	1	0	1	0
Δ	0	0	0	0	1	0	1	1
9	0	0	0	0	1	1	0	0
6	0	0	0	0	1	1	0	1
3	0	0	0	0	1	1	1	0
Space	0	0	0	0	1	1	1	1
LOCAL	0	0	1	1	0	0	0	0
PLOT	0	0	1	1	0	0	0	1
Blue	0	0	1	1	0	0	1	0
/	0	0	1	1	0	0	1	1
*	0	0	1	1	0	1	0	0
-	0	0	1	1	0	1	0	1
+	0	0	1	1	0	1	1	0
√	0	0	1	1	0	1	1	1
ENTER	0	0	1	1	1	0	0	0
Green	0	0	1	1	1	0	0	1
EXECUTE	0	0	1	1	1	0	1	0
m	0	0	1	1	1	0	1	1
μ	0	0	1	1	1	1	0	0
n	0	0	1	1	1	1	0	1
p	0	0	1	1	1	1	1	0
EEX	0	0	1	1	1	1	1	1

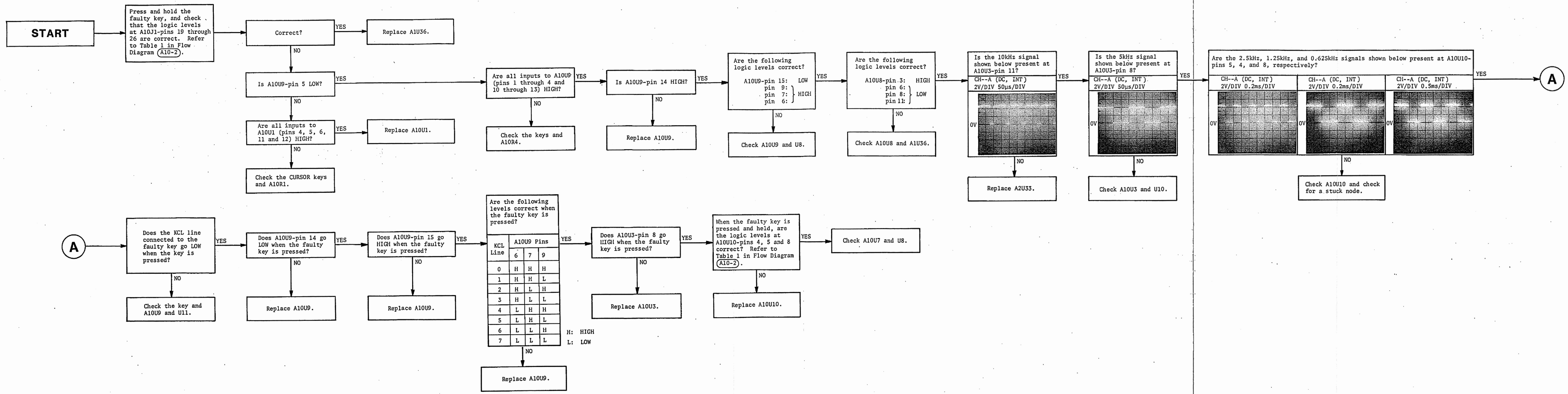
Key Name	26	25	24	23	22	21	20	19
FAST	0	1	0	0	0	0	0	1
→	0	1	0	0	0	0	1	0
↑	0	1	0	0	0	1	0	0
←	0	1	0	0	1	0	0	0
↓	0	1	0	1	0	0	0	0
All Keys off	1	0	0	0	0	-	-	-

0: LOW level

1: HIGH level

Figure 8-19. A10 Board Troubleshooting Flow Diagram (Sheet 2 of 3).

Flow Diagram (A10 - 3)



KCL Line	A10U9 Pins		
	6	7	9
0	H	H	H
1	H	H	L
2	H	L	H
3	H	L	L
4	L	H	H
5	L	H	L
6	L	L	H
7	L	L	L

P/O	Part of.
	Knob control.
	Screwdriver adjustment.
	Circuit assembly boarderline.
*	Asterisk denotes a factory selected value. Value shown is typical, part may be omitted.
	Bead inductance.
	Circuit board pattern inductance.
	Heavy line indicates main signal path.
	Heavy dashed line indicates main feedback path.
CW	Wiper moves towards CW with clockwise rotation of control (as viewed from shaft or knob).
1	Numbered test point. Measurement aid provided.
947	Denotes wire color code. Code used is the same as the resistor color code (e.g., 9.4.7 denotes white/yellow/violet).
	Indicates direct conducting connection to earth.
	Indicates conducting connection to chassis or frame.
	Indicates circuit common connection.
	Encloses front panel designations.
	Shielded area.

Figure 8-20. Schematic Diagram Notes.

8-36. A1 GRAPHIC DISPLAY CONTROL BOARD

8-37. The A1 board handles all data transfer operations between the 1345A Digital Display and the microprocessor on the A2 board. Data transfer is via a 16-bit data bus, which provides asynchronous handshake. The A1 board contains a 4K x 16-bit Display RAM, which functions as Option 704 of the 1345A. It is also used for the PLOT and PRINT functions. Refer to paragraphs 3-117 and 3-119, respectively. Figure 8-21 shows the overall block diagram of the A1 board.

[Display RAM]

The 1345A is controlled by 16-bit commands sent from the microprocessor and stored in the Display RAM, U29 - U32. The Display RAM stores all commands required to draw lines and alphanumeric characters on the CRT, and sequentially sends the stored commands to the 1345A. Display refresh is handled by the Scan Pointer and Jump Control. The Scan Pointer, U5 - U7, is incremented by the Timing Controller and addresses the RAM via the SCA 0 - 11 lines. When a "MEMORY JUMP" instruction (bit 15 = 1) is output from the RAM, Jump Control, U16 and U28, sets the Scan Pointer to the restart address.

[Write Operation]

To draw a new figure on the CRT, the R/W Memory Pointer, U25 - U27, addresses the RAM and data is sent from the microprocessor to the RAM via the 8-line/16-line converter, U41 and U42.

[Read Operation]

When the PLOT key is pressed, display data stored in the RAM is output to the HP-IB via the 16-line/8-line converter, U43 and U44.

[Self Test]

Self-test checks the operation of the A1 Board. U19 and U20 return the output data to the microprocessor to confirm the write operation. Also, the Monitor Buffer, U38 and U39, returns the R/W address and handshake control line to the microprocessor.

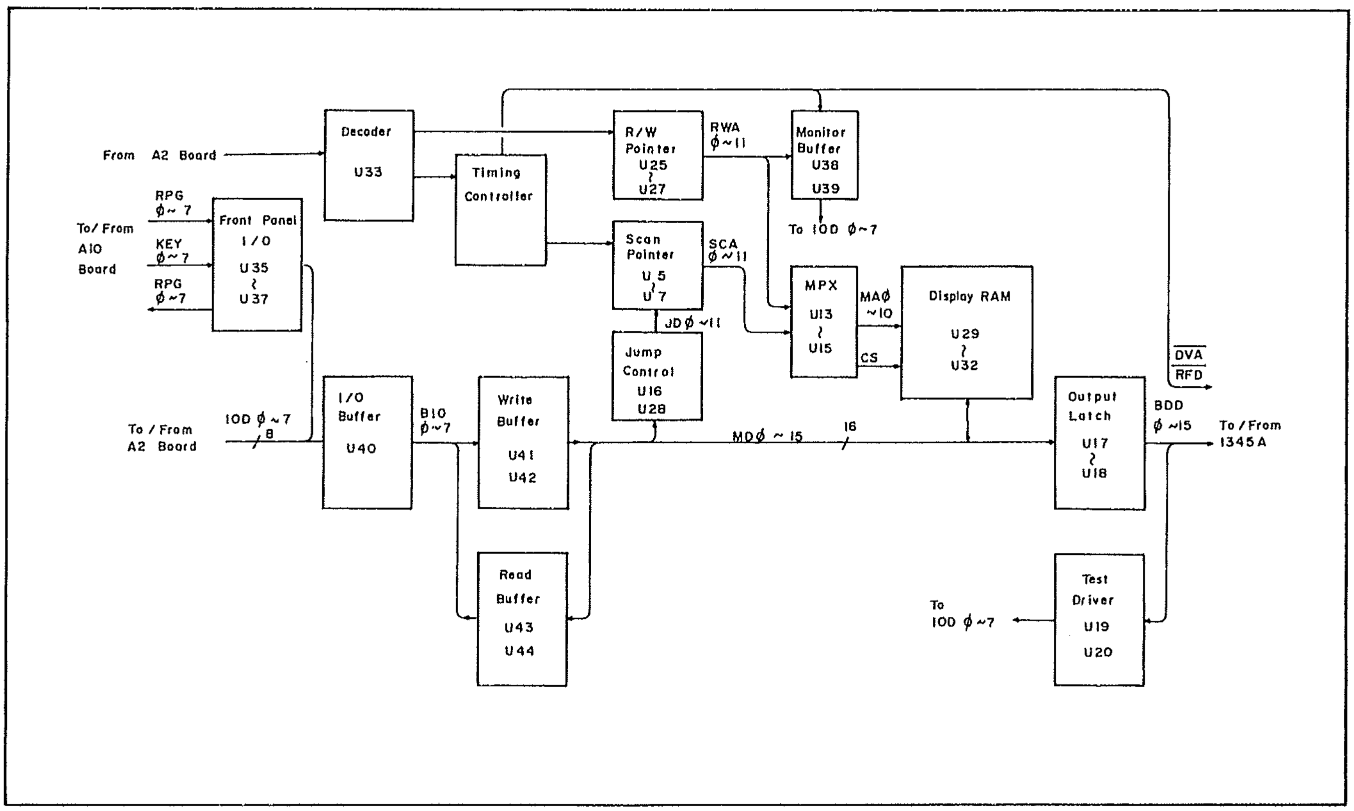


Figure 8-21. Block Diagram of A1 Board.

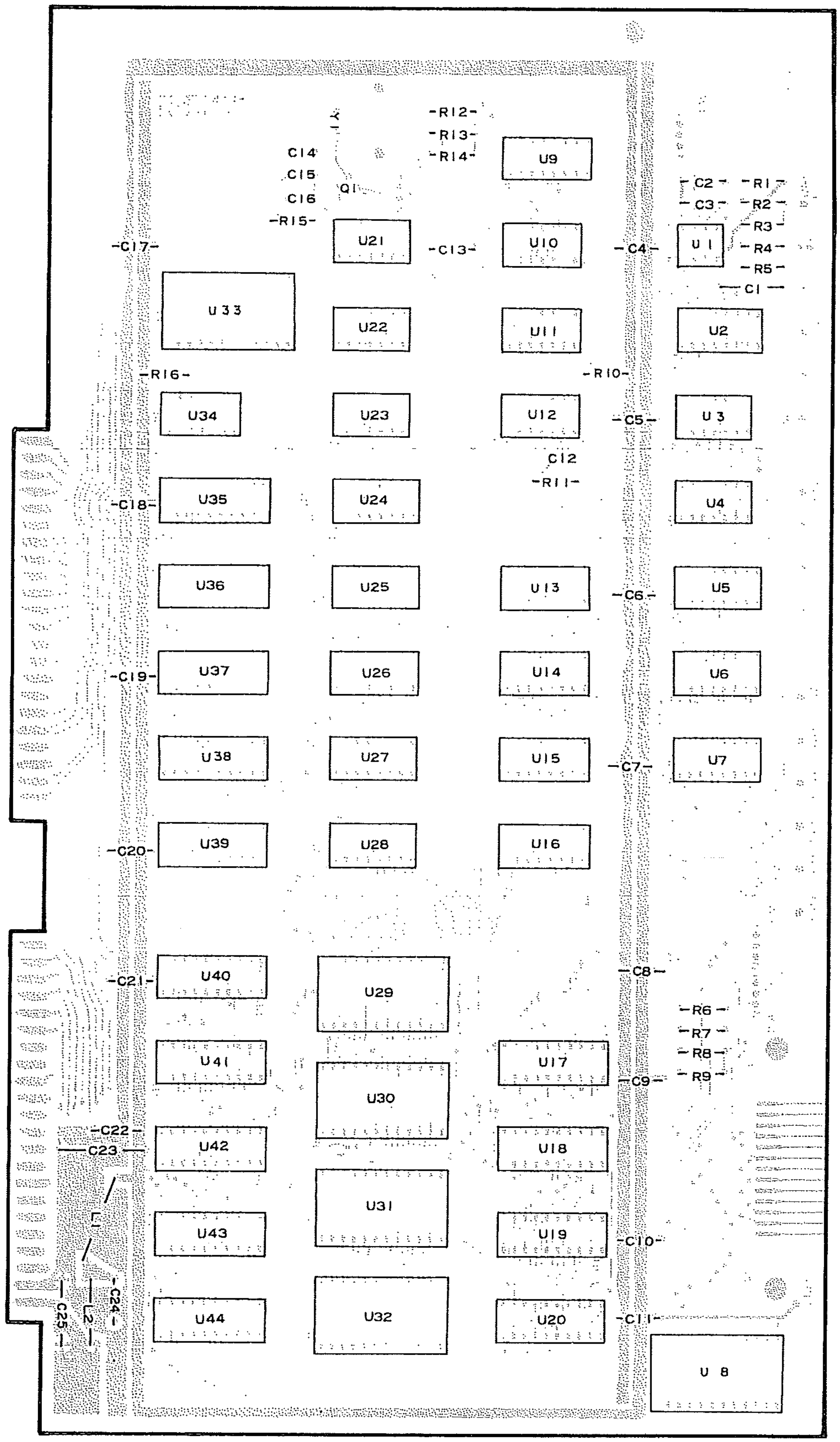
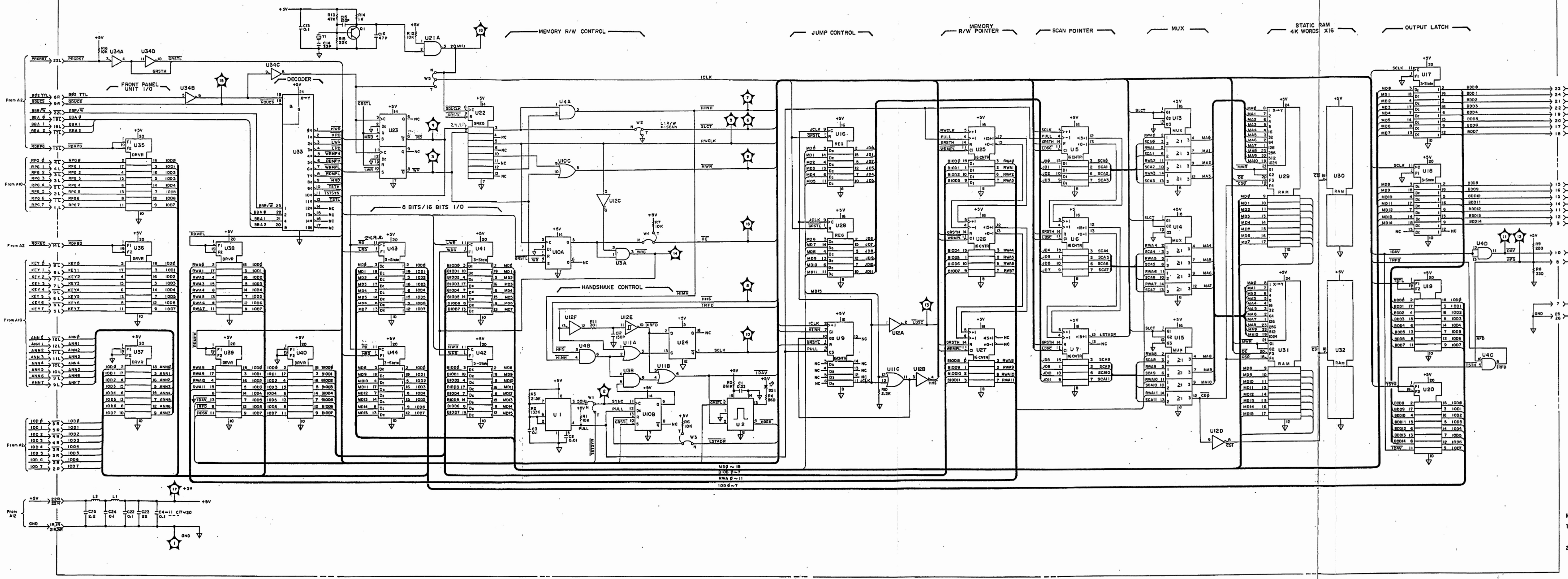


Figure 8-22. A1 Graphic Display Control Board Assembly Component Locations.

A1 GRAPHIC DISPLAY CONTROL (P/N:04145-66501)



NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
2. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS (Ω)
   CAPACITANCE IN MICROFARADS (μF)
   INDUCTANCE IN MICROHENRIES (μH)

8-38. A2 MICROPROCESSOR DIGITAL CONTROL BOARD

8-39. The A2 board contains the host microprocessor and provides overall instrument control. Figure 8-24 shows the block diagram of the A2 board.

Basic software routines are stored in the 16k byte ROM (U13, U14, U26 and U27) and consist, mainly, of monitor programs and subprograms for the flexible-disc drive, graphics display unit, and HP-IB.

Operating system software, recorded on the flexible disc, is loaded into the 32k byte dynamic RAM (U5 through U12, and U18 through U25) when the 4145A is turned on.

Data transfer to and from the microprocessor on the A3 board is performed serially via the asynchronous communication interface adapter (ACIA), U58. Ground isolation between the A2 board and the A3 board is maintained by optocouplers on the A3 board. Data transfer to and from the A1 and A9 boards, however, is via the 8-bit bidirectional data bus (IOD 0 - 7).

Timing for all instrument operations is controlled by the clock generator U15 and the clock divider circuit—U46, U48 and U49.

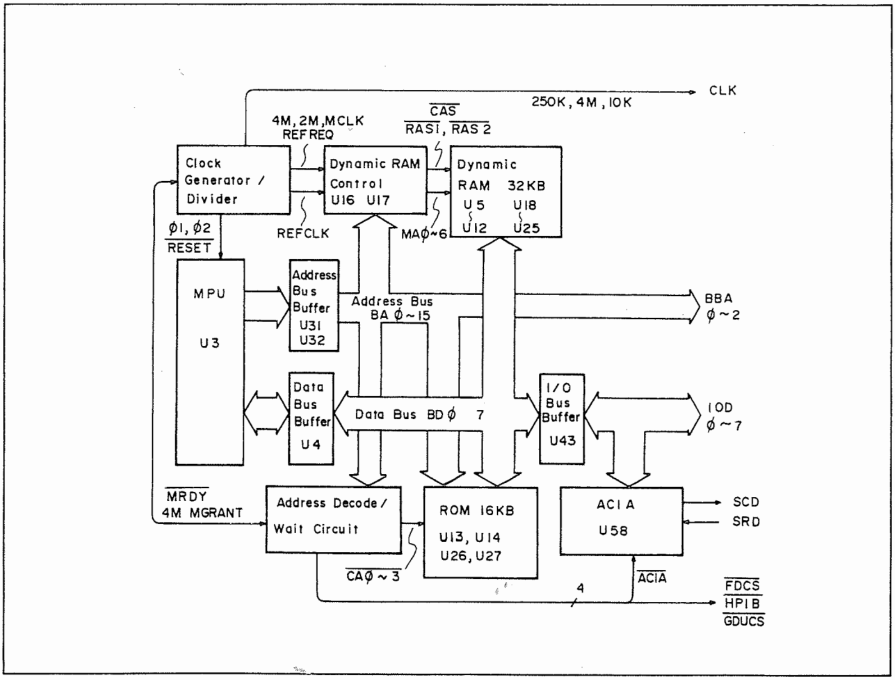


Figure 8-24. Block Diagram of the A2 Board.

[Signal Identification]

IOD 0 - 7 (I/O Data Bus):
Bidirectional data bus lines

BBA 0 - 2 (Address Lines):
Lower 3 bits of the external I/O address bus

Control Lines:
Bϕ2 TTL:
Timing signals between the MPU and external I/O

BBR/$\overline{\text{W}}$:
Read/Write signal for external I/O

Chip Select:
$\overline{\text{HP-IB}}$: HP-IB select signal

$\overline{\text{FDCCS}}$: FDD controller select signal

$\overline{\text{GDUCS}}$: A1 board I/O select signal for the 1345A

Strobe Signal:
$\overline{\text{LATCHA}}$, $\overline{\text{LATCHB}}$:
Select signal for the display latches on the A10 board.

$\overline{\text{RDKBD}}$: A1 board I/O select signal for the keyboard

$\overline{\text{RDRPG}}$: A1 board I/O select signal for the RPG

Latched Control Signals:
$\overline{\text{FDSEL}}$: Enables the FDD.

$\overline{\text{PRGRST}}$ (Program Reset):
Reset signal from the program being executed.

Serial Communication Lines:
SCD (Serial Command Data):
Signal to the A3 board

SRD (Serial Response Data):
Signal from the A3 board

SCK (Serial Clock):
Clock for serial data transfer

Clock Signals:
B4MHz: Clock for the FDD circuit
KEYCLK: Scan clock for the keyboard

Direct Input Signals:
OPEN/CLOSE:
Sense signal for the test fixture lid

Interrupt Request Lines:
$\overline{\text{PERIRQ}}$ (Peripheral Interrupt Request):
Interrupt signal from HP-IB and FDD.

$\overline{\text{PWRFAIL}}$ (Power Fail):
Signal which indicates transient power loss.

Reset Signal:
$\overline{\text{RESET}}$: Reset signal when the instrument is turned on.

Test Control Signal:
$\overline{\text{INH}}$: External clock select signal

EXTIN: External clock signal

$\overline{\text{HALT}}$: Halt signal for the MPU

EXTBA: Address bus enable signal when the MPU is halted.

[Software]

Software for the 4145A is divided into three parts: OS (Operating System), Utility Programs, and Tasks (Application Program).

OS consists of the following programs:

Task Control Program
Timer Control Program
I/O Control Program
Interrupt Control Program
Program Control Program
Arithmetic Control Program
Initialize Control Program

Utility Programs consist of subroutines used by the Application Programs.

A task is the minimum unit of a program, and is controlled by the OS. The 4145A can perform various jobs by performing various Tasks. Following are key Tasks which control lower level Tasks:

Keyboard Task
RPG Task
HP-IB Task
Page Control Task
ASP Interpreter

Table 8-5 (Fold-out page) lists the program locations. All programs are initially stored in the ROM or on the disc. Programs on the disc are divided into 12 files, files 0 through 11. Files 0 through 3 are loaded into the RAM when the instrument is turned on. The other programs are loaded into the RAM when necessary.

Table 8-5. Program Locations

ROM No. File No.	Primary Program Contents
ROM U26	Utility Program, Keyboard Task, SMU control
ROM U27	HP-IB, I/O control
ROM U13	FDD, HP-IB
ROM U14	OS, Keyboard, Self-Test
File 0*	Page control, Utility Program
File 1*	SOURCE SETUP page, MEAS & DISP MODE SETUP page
File 2*	GRAPHICS PLOT page, Measurement control
File 3*	Mathematics control, Interpreter/Translater
File 4	Graphics Analysis control
File 5	LIST DISPLAY page, MATRIX DISPLAY page, SCHMOO PLOT page
File 6	PLOT, OUTPUT SEQ SETUP page
File 7	Data display, ASP Editor
File 8	OPERATION GUIDE page
File 9	CATALOG page, DIAGNOSTICS page
File 10	User graphics
File 11	MENU page, DEFINITION page

* All Files are stored on the disc. File 0 through File 3 are stored in the RAM when the 4145A is turned on.

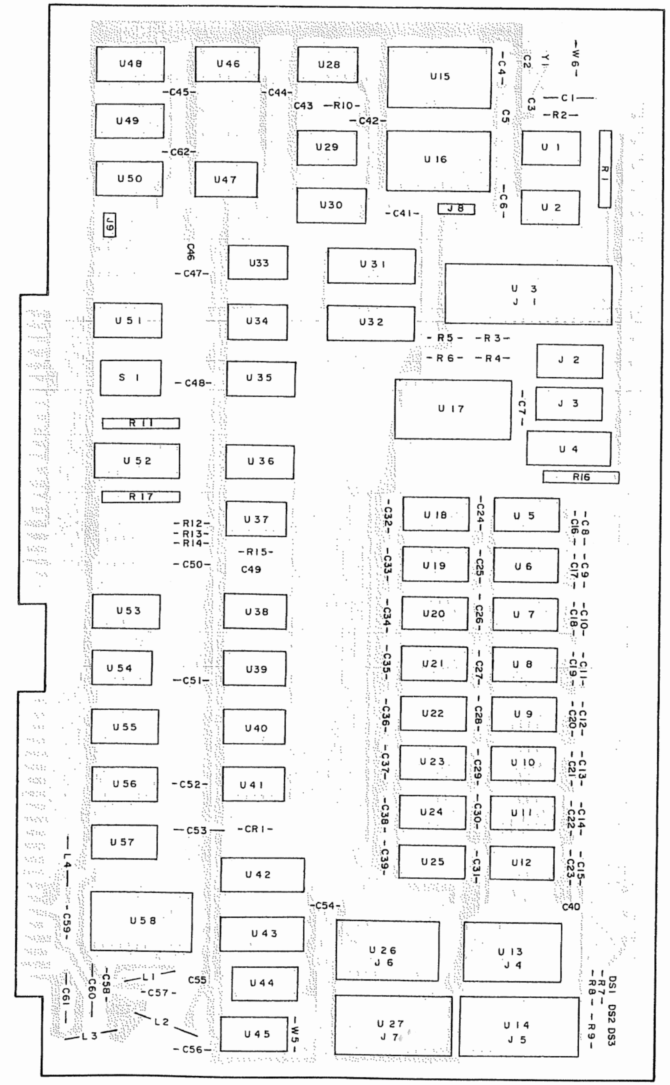
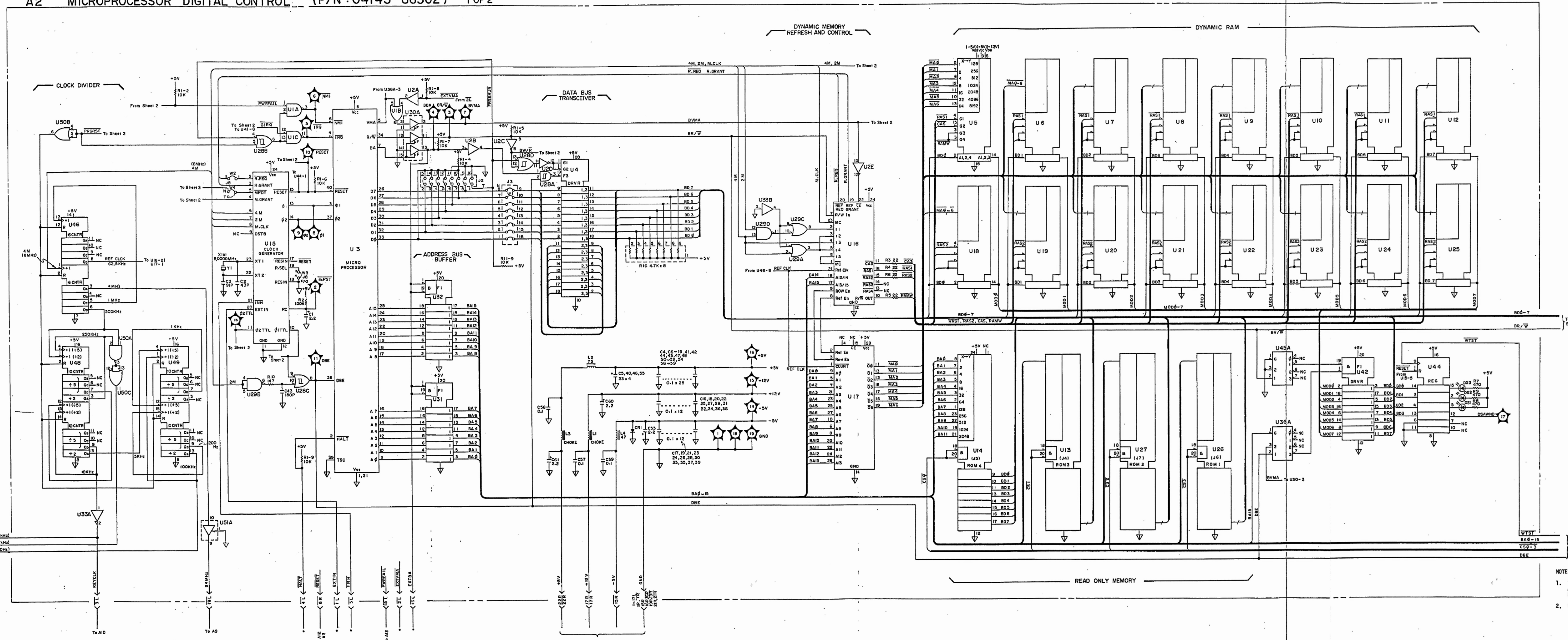


Figure 8-25. A2 Microprocessor Digital Control Board Assembly Component Locations.

A2 MICROPROCESSOR DIGITAL CONTROL (P/N:04145-66502) 1 OF 2



NOTES:

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2. UNLESS OTHERWISE INDICATED:

RESISTANCE IN OHMS (Ω)
CAPACITANCE IN MICROFARADS (μF)
INDUCTANCE IN MICROHENRIES (μH)

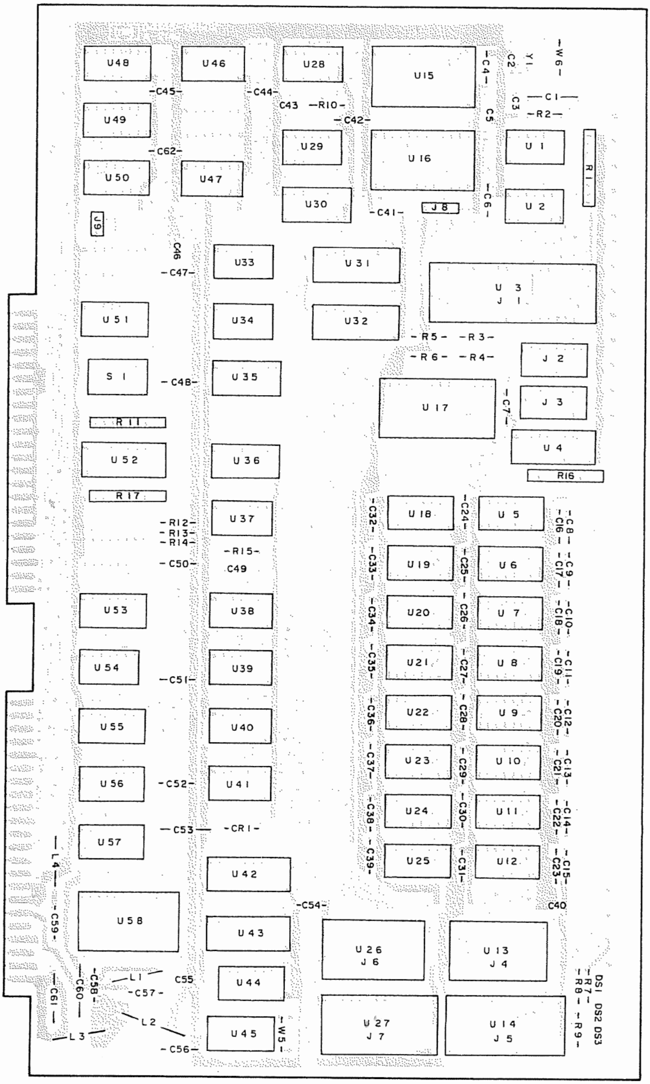
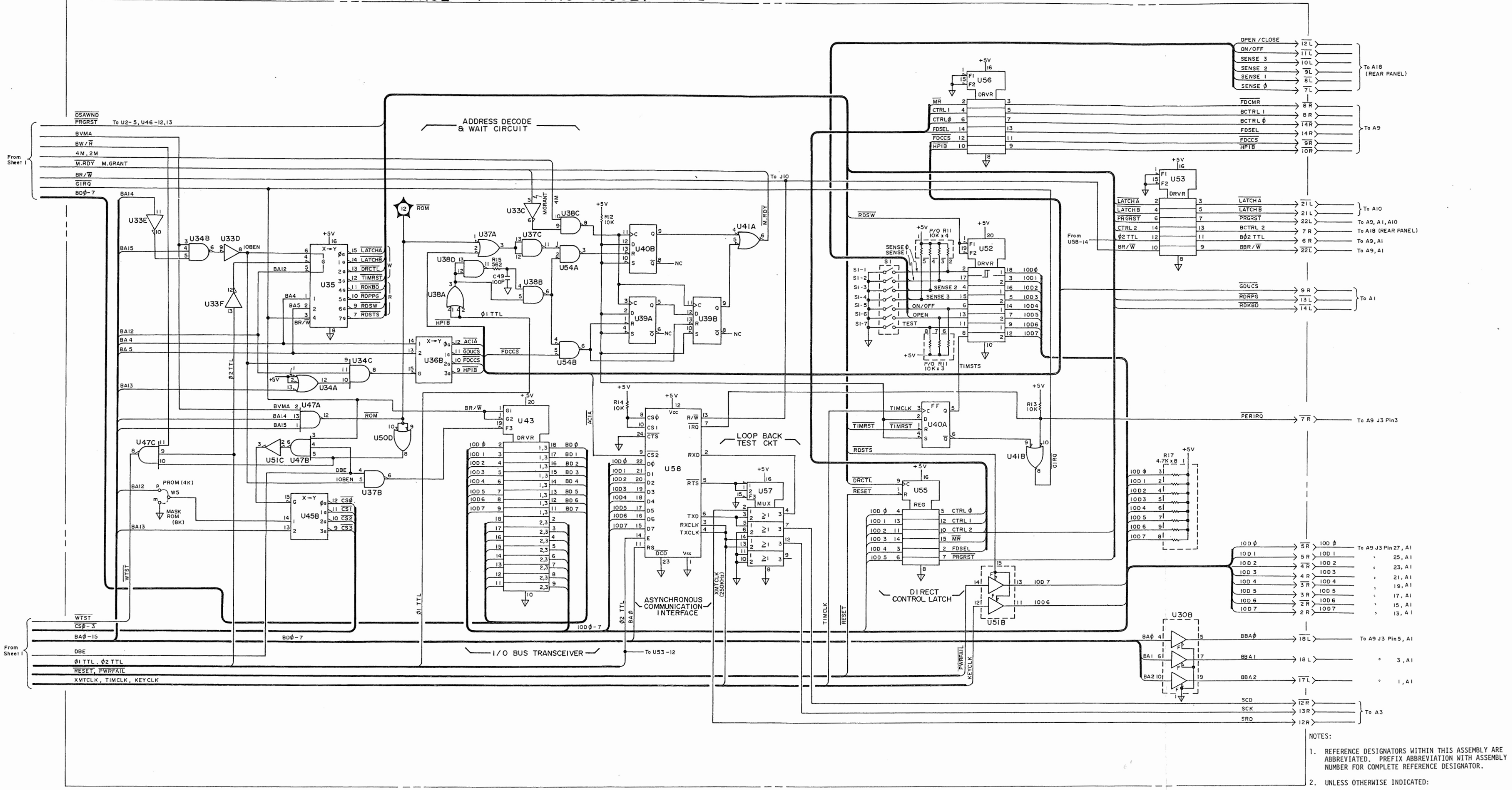


Figure 8-25. A2 Microprocessor Digital Control Board Assembly Component Locations.

A2 MICROPROCESSOR DIGITAL CONTROL (P/N:04145-66502) 2OF2



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2. UNLESS OTHERWISE INDICATED:

RESISTANCE IN OHMS (Ω)
CAPACITANCE IN MICROFARADS (μF)
INDUCTANCE IN MICROHENRIES (μH)

A2 BOARD

Figure 8-26. A2 Microprocessor Digital Control Board Assembly Schematic Diagram (Sheet 2 of 2).

8-40. A3 A-D CONVERTER BOARD

8-41. The A3 board controls the SMUs, voltage sources, and voltage monitors as directed by the microprocessor on the A2 board. It contains a 16-bit successive approximation ADC and a microprocessor based digital control section.

Figure 8-27 (a) shows the block diagram of the ADC. The voltage and current monitor signals from the SMUs and voltage monitors, which are normalized to ±10 volts full scale, are applied directly to the inputs of the multiplexer, U37. The control register, U31, instructs the multiplexer to sequentially select each valid input for A-to-D conversion.

Note

> Only inputs from SMUs and voltage monitors that are used in the measurement (have been assigned on the CHANNEL DEFINITION page) are valid. Outputs from unused SMUs and voltage monitors are not selected for A-to-D conversion. Also, the order in which the inputs are selected is determined by the order specified on the OUTPUT SEQUENCE SETUP page (see Figure 3-29).

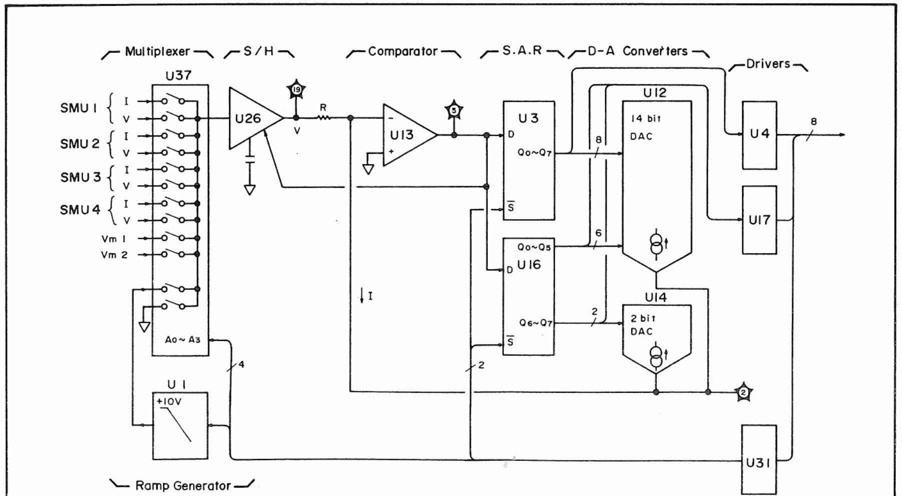
The selected input is applied to the sample-hold circuit, U26 and U29B, and is held until A-to-D conversion is completed. The A-to-D conversion process is briefly described below

(1) The first clock pulse resets the DAC (U2 and U14) and the SAR (U3 and U16), so that the MSB of the DAC is 1 and all others are 0. Thus, the output from the DAC is half of full scale.

(2) The outputs from the DAC and the sample-hold circuit are compared by the comparator, U13. If the output from the sample-hold circuit is greater than the DAC output, the MSB of the SAR will remain at 1 and the next lower bit will be set to 1 on the next clock pulse. If otherwise, the MSB will be set to 0 and the next lower bit will be set to 1.

(3) Step (2) is repeated until the LSB of the DAC has been set.

(4) The SAR then sets the comparison-complete bit HIGH, informing the microprocessor that A-to-D conversion is finished.



(a) A-D Converter Section

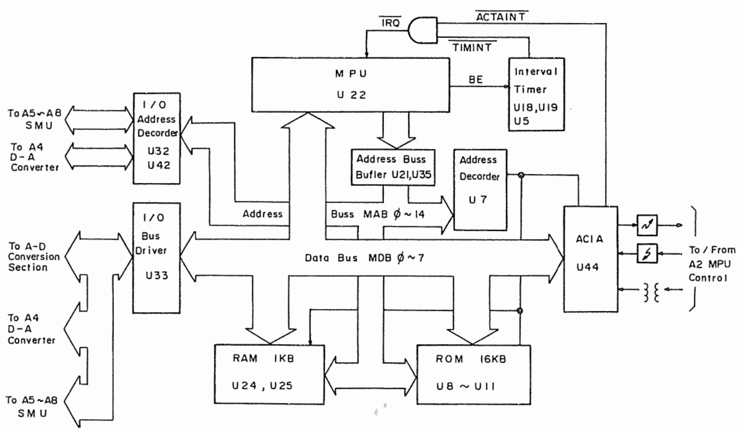
Figure 8-27. Block Diagram of the A3 Board.

(5) The microprocessor read the value in the SAR, which is the digital value of the analog voltage.

The 16-bit DAC consists of two separate DACs. One is a 16-bit DAC (U2) wired for 14-bit operation. It provides only the lower-order 14-bits in order to improve A-to-D conversion monotonicity. The other is an 8-bit DAC (U14) wired for 2-bit operation. It provides the two higher-order bits and extends the measurement range of the 14-bit DAC.

To maintain optimum accuracy at all times, the DAC is automatically calibrated every minute. The ramp generator, U1, is used for this. It establishes accurate reference levels for each DAC range. Also, comparison with ground is performed to establish and accurate ground reference.

Figure 8-27 (b) shows the block diagram of the digital control section of the A3 Board. The digital section mainly contains of an 8-bit MPU (Microprocessor Unit), four 12k Byte ROMs, two 1k Byte RAMs, Address Decoder, ACIA (Ascynchronous Communication Interface Adapter), optocouplers, and Interval Timer.



(b) Digital Control Section

Figure 8-27. Block Diagram of the A3 Board.

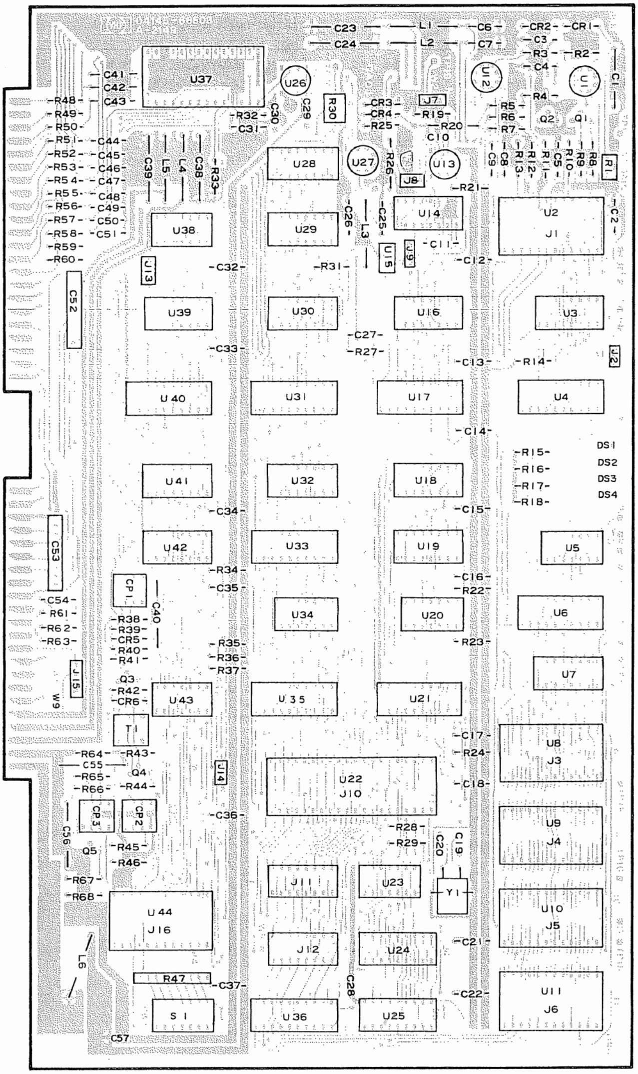
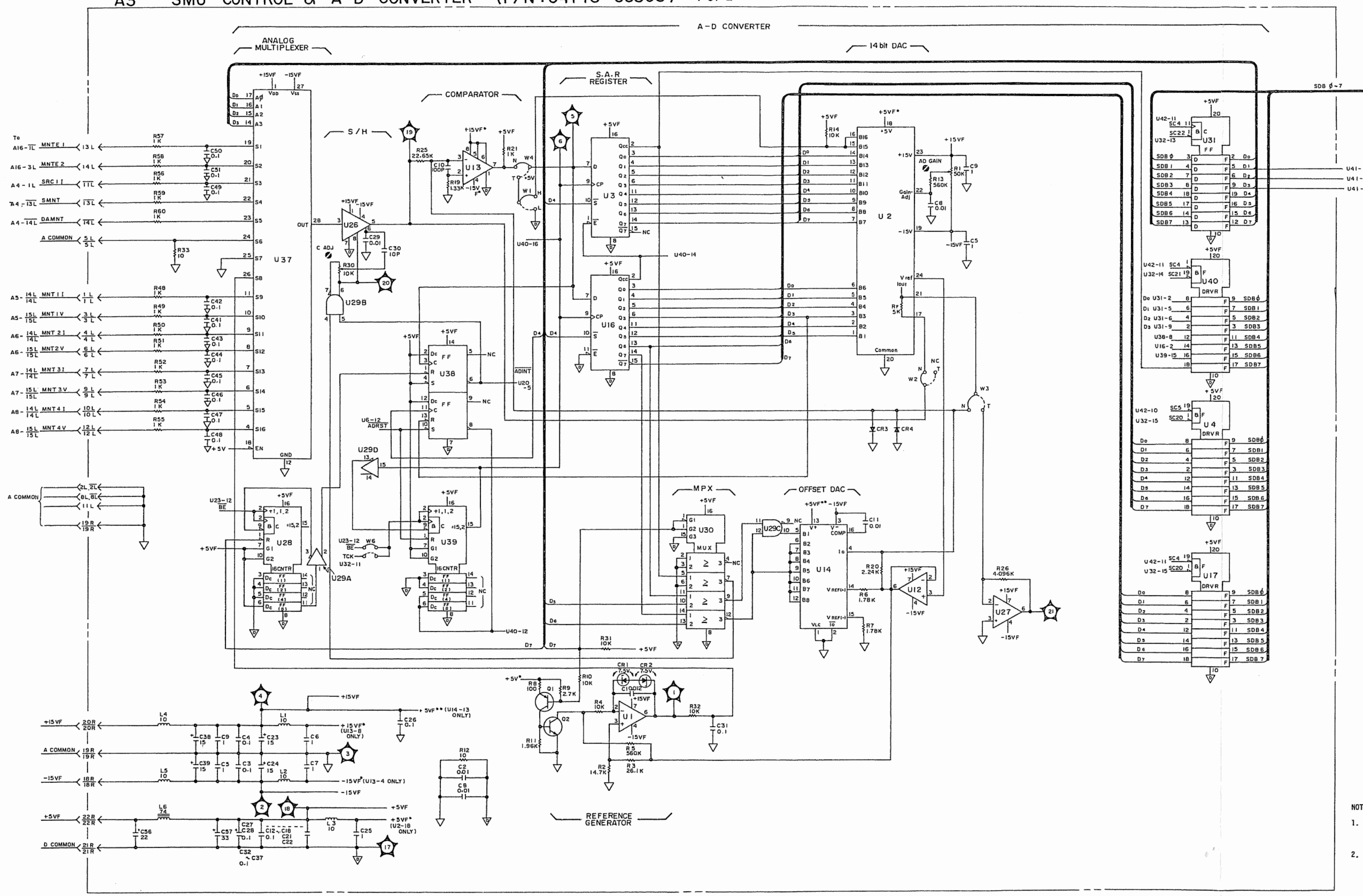


Figure 8-28. A3 SMU Control and A-D Converter Board Assembly Component Locations.

A3 SMU CONTROL & A-D CONVERTER (P/N:04145-66503) 1 OF 2



NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
2. UNLESS OTHERWISE INDICATED:

   RESISTANCE IN OHMS (Ω)
   CAPACITANCE IN MICROFARADS (μF)
   INDUCTANCE IN MICROHENRIES (μH)

A3 BOARD

Figure 8-29. A3 SMU Control and A-D Converter Board Assembly Schematic Diagram (Sheet 1 of 2).

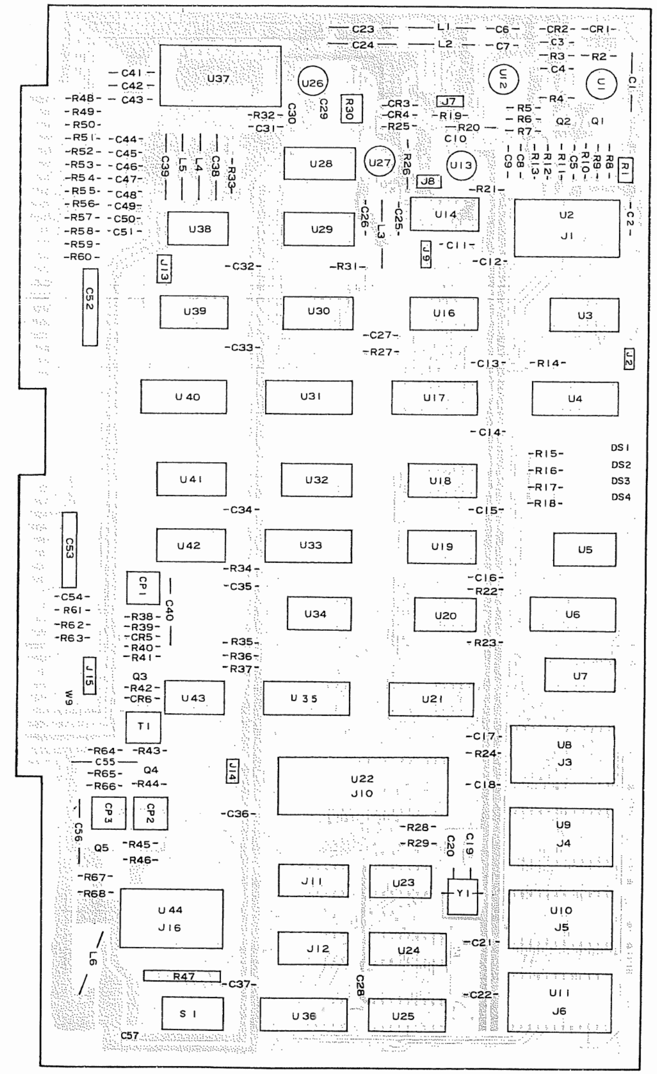
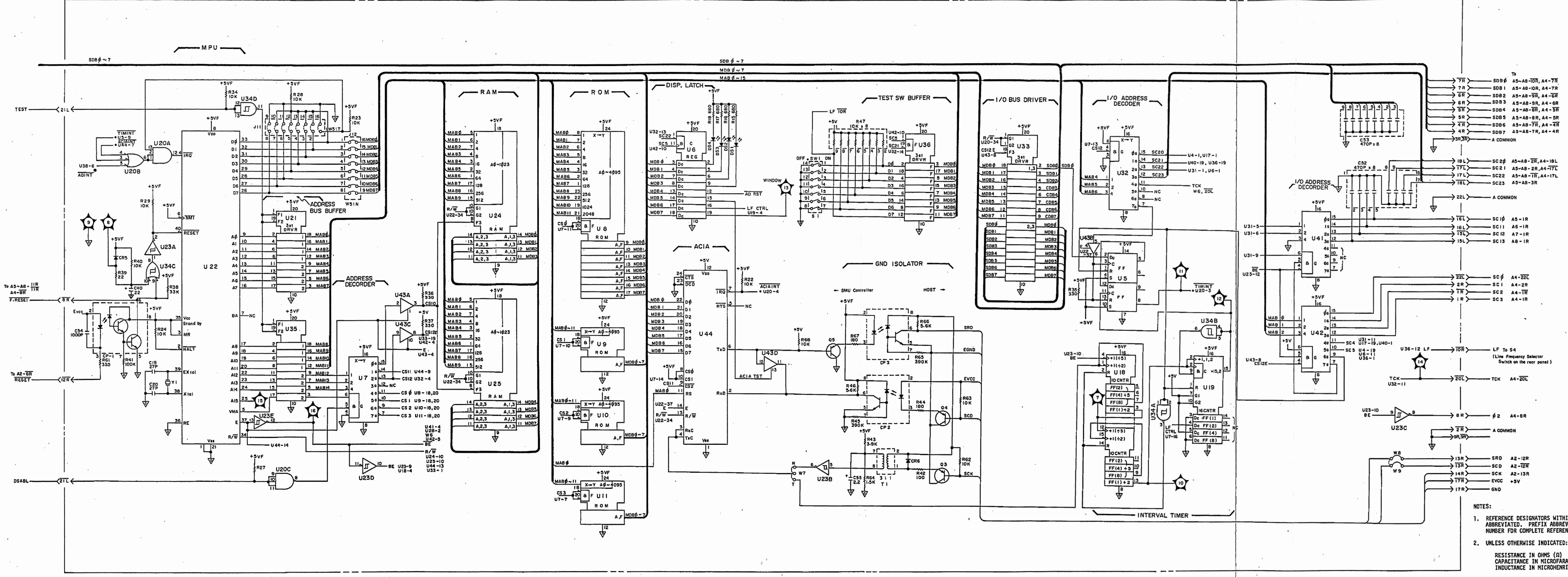


Figure 8-28. A3 SMU Control and A-D Converter Board Assembly Component Locations.

A3 SMU CONTROL & A-D CONVERTER (P/N:04145-66503) 2OF2



NOTES:

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2. UNLESS OTHERWISE INDICATED:

RESISTANCE IN OHMS (Ω)
CAPACITANCE IN MICROFARADS (μF)
INDUCTANCE IN MICROHENRIES (μH)

8-42. A4 D-A CONVERTER BOARD

8-42. Figure 8-30 shows a simplified block diagram of the A4 board. It consists of four 64-bit static RAMs, a 16-bit D-A converter, an I-V converter, a 10-channel demultiplexer, and ten sample-hold circuits. The entire board functions to provide the requisite reference voltages for the four SMUs and the two voltage sources. All reference voltages provided by this board are determined by the digital data sent from the A3 board and are normalized to values ranging from 0 to ±10V. Resolution is 0.5mV.

Output data (voltage and current values) set on the SOURCE SETUP page (refer to Figure 3-22) are sent from the A3 board and stored in the four RAMs--U19, U20, U25 and U26. The 16-bit D-A converter--U18 and U24--and the I-V converter--U6, Q1 and Q2--convert the digital data output from the RAMs into an analog voltage, which is then applied to the input of the appropriate sample-hold circuit by the 10-channel demultiplexer.

Other circuits on this board are the Multiplex Timing Controller, which handles RAM Read/Write addressing and demultiplexer timing; the Bus Interface for data memory; SMU Loop Change Detector, which monitors the operation mode (V or I) of each SMU; and the Test Switch circuit, which is used during self-test to check the D-A converter.

[D-A Converter]

The D-A converter on this board consists of a 14-bit D-A converter, U18, and an 8-bit offset D-A converter, U24, wired for 2-bit operation. It is similar to the D-A converter on the A3 board. Output from the D-A converter is a current that is proportional to the binary value provided by the RAMs.

[I/V Converter]

Because the DAC is a current driven type, an I/V converter is used to convert the output current into voltage. Figure 8-31 shows the output waveform at TP1 when the 4145A is in an idle condition (measurement is not being made).

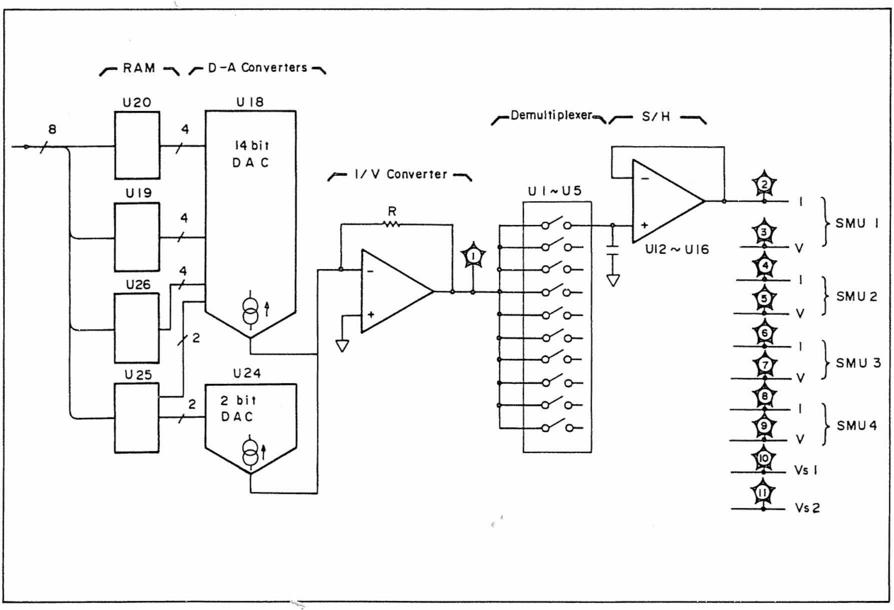


Figure 8-30. Block Diagram of A4 Board.

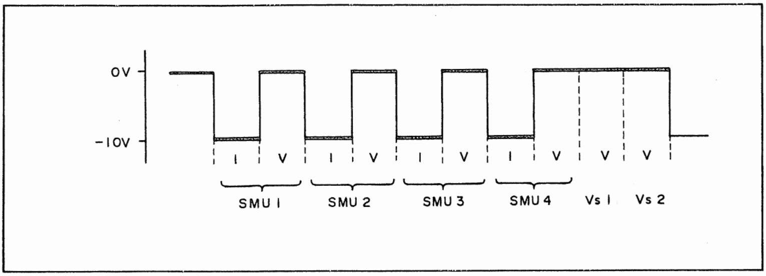


Figure 8-31. I-V Converter Output.

[Demultiplexer]

The demultiplexer contains analog switches, U1 through U5, and distributes the ten reference voltages provided by the DAC and I/V converter to appropriate sample-hold circuit. Figure 8-32 shows circuitry for each demultiplexer channel. Two FET switches are driven by a control signal provided by the Timing Controller. To isolate the sample-hold circuit in sample mode from the I/V converter, an isolation capacitor is connected between the two switches. Also, to cancel the drive signal transmitted through gate-drain capacitor of the FET switch, an opposite signal is applied through the injection capacitor.

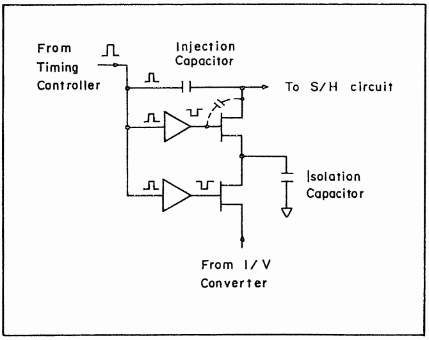


Figure 8-32. Analog Switch.

[Loop Back Test]

The test switch selector, U33, and the test switches--U30, U31 and U32--are used during the loop back test portion of the self-test. The loop back test confirms correct operation of the A4 D-A converter and the A3 A-D converter.

When self-test is executed, the microprocessor on the A3 board stores a predetermined binary value in the A4 RAMs. The DAC converts this value into an analog voltage which is distributed to each output channel by the demultiplexer. The test switch selector controls the test switches so that each channel is, in turn, selected for output to the ADC on the A3 board. After A-D conversion, the microprocessor compares the original binary value with that output from the ADC, thus confirming correct DAC and ADC operation.

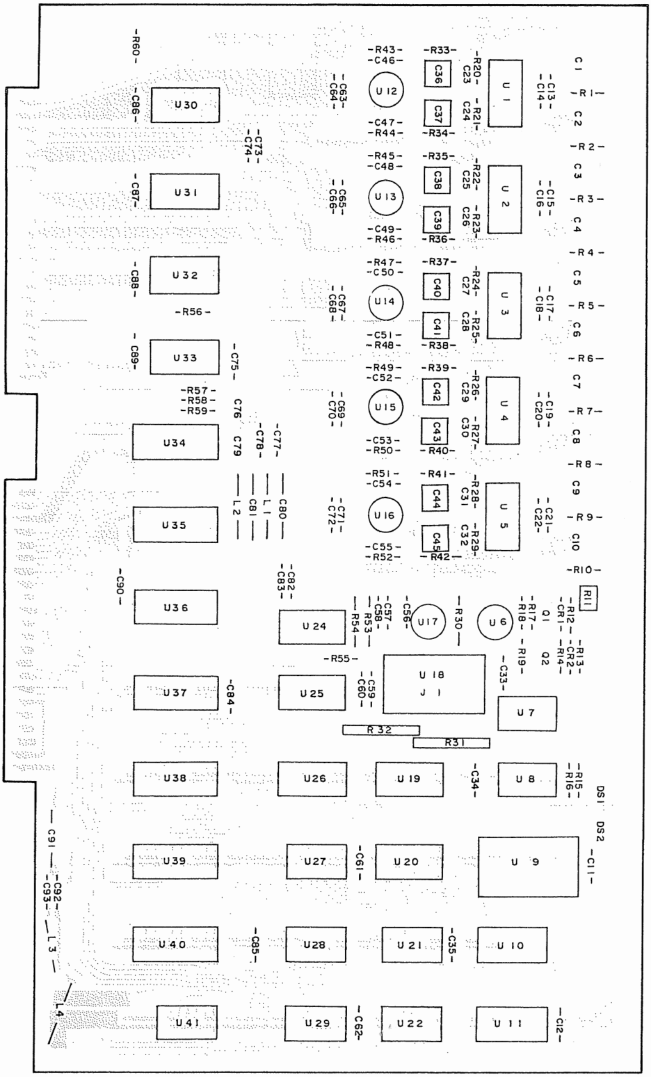
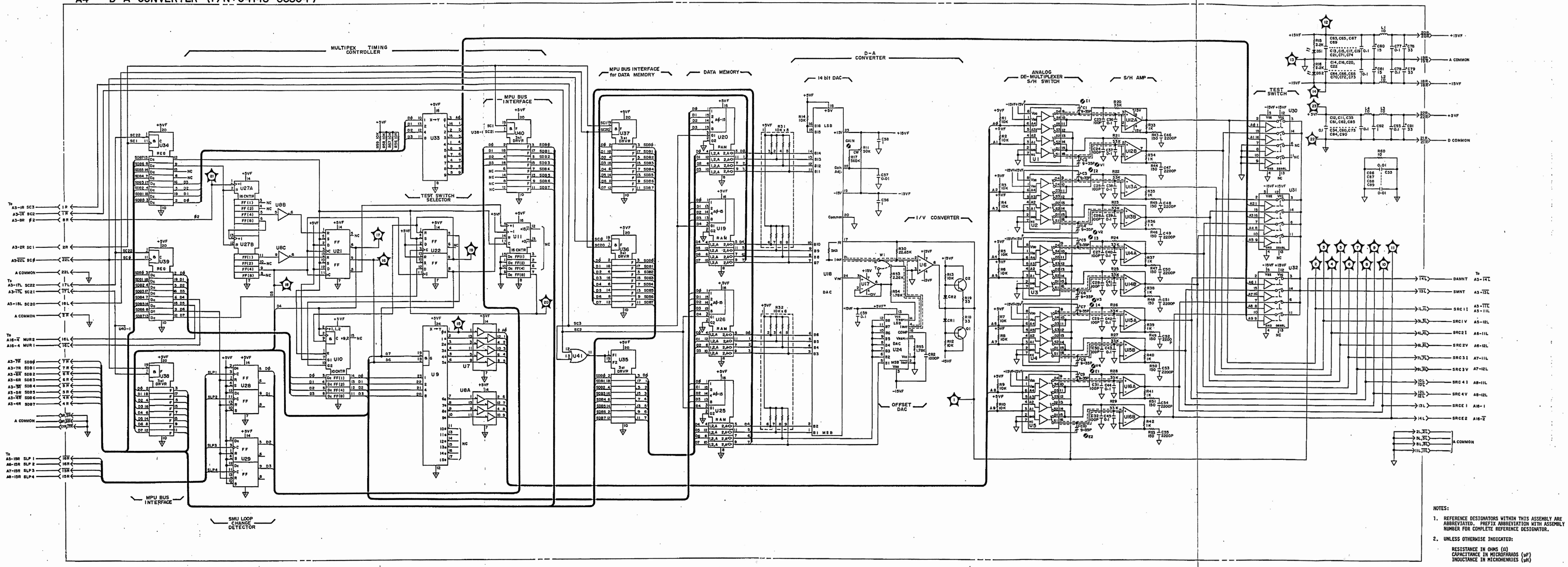


Figure 8-33. A4 D-A Converter Board Assembly Component Locations.

A4 D-A CONVERTER (P/N:04145-66504)



NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.

2. UNLESS OTHERWISE INDICATED:

RESISTANCE IN OHMS (Ω)
CAPACITANCE IN MICROFARADS (μF)
INDUCTANCE IN MICROHENRIES (μH)

Flow Diagram (A5 - 1)

START

1) Turn on the 4145A.
2) Warm up at least 40 minutes.
3) Short the SMU output. See Fig. A.
4) Perform Self-Test (refer to Figure 3-32).

Does the 4145A pass Self-Test?
- YES → Turn off the 4145A. Interchange the faulty SMU board with another SMU board. Turn on the 4145A. → Does the symptom move to another channel?
  - YES → (A)
  - → What is the symptom?
    - No output → Check A19, output cable and output connector.
    - Large current can not be measured or output. → ±4V supply from A13 is not correct. → Go to Flow Diagram (A13).
    - Tends to oscillate. → Capacitance between SMU output and Guard is too high. → Check the SMU output cable.
    - Out of specs in small current measurement. → Does the symptom move to another channel if the triaxial cable is interchanged?
      - YES → Leakage in the Test Fixture and triaxial cable.
      - NO → Leakage on A19, and output connector on the rear panel.
- NO → Does the 4145A pass Self-Test if the SMU Test Adapter is removed?
  - YES → Does the 4145A pass Self-Test if the J2 cable is interchanged with that of another SMU.
    - YES → Check A19, and SMU Test Adapter.
    - NO → K8 is "making" during Selt-Test. → Is the voltage between TP10 and U15 pin 2 0V during Self-Test?
      - YES → Replace K8.
      - NO → Replace U15 and also check U16.
  - NO → Does the 4145A pass Self-Test if J2 of the faulty channel is disconnected?
    - YES → Check the A19 Board, cable and connector.
    - NO → Are all voltages at J1 correct? Refer to Fig. B.
      - YES → Which error number is displayed (refer to "SMU Status" in Figure 3-20)?

1	Go to Flow Diagram (A5-2)
2	Go to Flow Diagram (A5-3)
3	Go to Flow Diagram (A5-4)
4	Go to Flow Diagram (A5-5)
5	Go to Flow Diagram (A5-6)
6	Go to Flow Diagram (A5-7)
7	Go to Flow Diagram (A5-8)

      - NO → Go to Flow Diagram (A13).

To short the SMU output, use the SMU Test Adapter (P/N 04145-65001), BNC Shorting Connector (P/N 04145-65002) and BNC (m) -to-BNC (m) adapter. Connection is shown below:

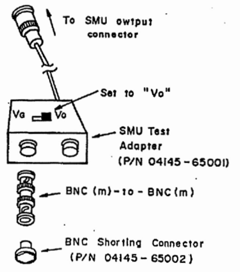


Figure A

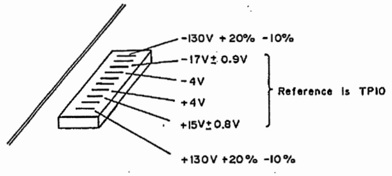
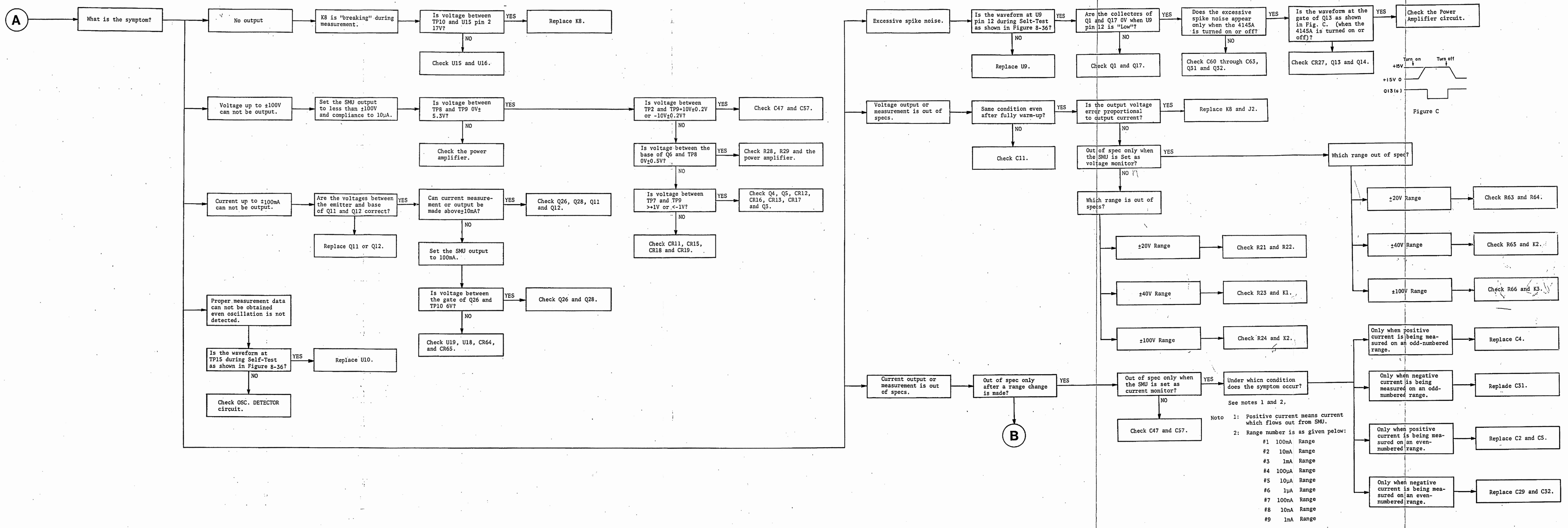


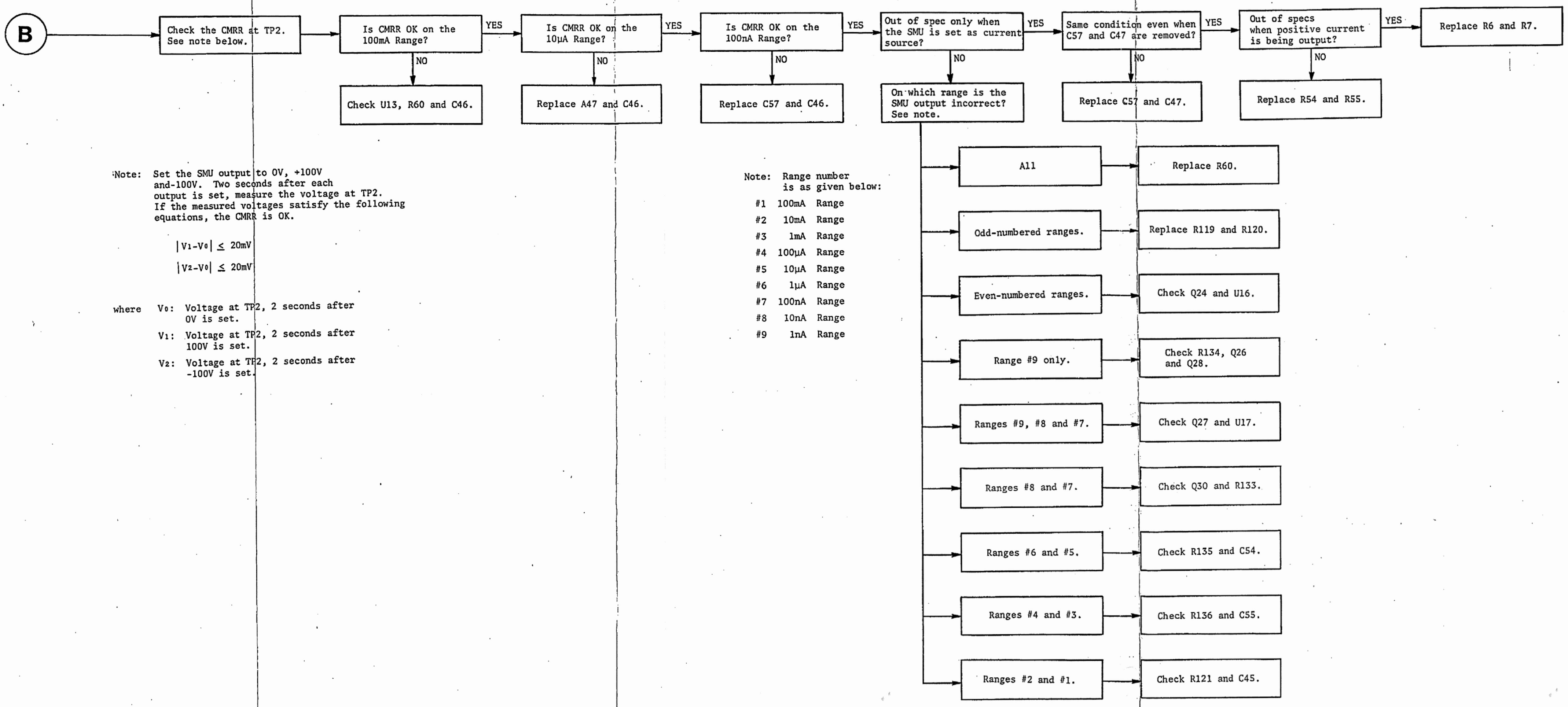
Figure B

A4 BOARD
SEE INSIDE

Figure 8-34. A4 D-A Converter Board Assembly Schematic Diagram.

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 1 of 9).


A
What is the symptom?
No output
K8 is "breaking" during measurement.
Is voltage between TP10 and U15 pin 2 17V?
YES
Replace K8.
NO
Check U15 and U16.
Voltage up to ±100V can not be output.
Set the SMU output to less than ±100V and compliance to 10µA.
Is voltage between TP8 and TP9 0V± 5.3V?
YES
NO
Check the power amplifier.
Is voltage between TP2 and TP9+10V±0.2V or -10V±0.2V?
YES
Check C47 and C57.
NO
Is voltage between the base of Q6 and TP8 0V±0.5V?
YES
Check R28, R29 and the power amplifier.
NO
Is voltage between TP7 and TP9 >+1V or <-1V?
YES
Check Q4, Q5, CR12, CR16, CR13, CR17 and Q3.
NO
Check CR11, CR15, CR18 and CR19.
Current up to ±100mA can not be output.
Are the voltages between the emitter and base of Q11 and Q12 correct?
YES
Replace Q11 or Q12.
Can current measurement or output be made above±10mA?
YES
Check Q26, Q28, Q11 and Q12.
NO
Set the SMU output to 100mA.
Is voltage between the gate of Q26 and TP10 6V?
YES
Check Q26 and Q28.
NO
Check U19, U18, CR64, and CR65.
Proper measurement data can not be obtained even oscillation is not detected.
Is the waveform at TP15 during Self-Test as shown in Figure 8-36?
YES
Replace U10.
NO
Check OSC. DETECTOR circuit.
Excessive spike noise.
Is the waveform at U9 pin 12 during Selt-Test as shown in Figure 8-36?
YES
NO
Replace U9.
Are the collectors of Q1 and Q17 0V when U9 pin 12 is "Low"?
YES
NO
Check Q1 and Q17.
Does the excessive spike noise appear only when the 4145A is turned on or off?
YES
NO
Check C60 through C63, Q31 and Q32.
Is the waveform at the gate of Q13 as shown in Fig. C. (when the 4145A is turned on or off)?
YES
Check the Power Amplifier circuit.
Check CR27, Q13 and Q14.
Turn on
Turn off
+15V
+15V 0
Q13(s)
Figure C
Voltage output or measurement is out of specs.
Same condition even after fully warm-up?
YES
NO
Check C11.
Is the output voltage error proportional to output current?
YES
Replace K8 and J2.
NO
Out of spec only when the SMU is Set as voltage monitor?
YES
Which range out of spec?
±20V Range
Check R63 and R64.
±40V Range
Check R65 and K2.
±100V Range
Check R66 and K3.
NO
Which range is out of specs?
±20V Range
Check R21 and R22.
±40V Range
Check R23 and K1.
±100V Range
Check R24 and K2.
Current output or measurement is out of specs.
Out of spec only after a range change is made?
YES
NO
B
Out of spec only when the SMU is set as current monitor?
YES
NO
Check C47 and C57.
Under whicn condition does the symptom occur?
See notes 1 and 2.
Only when positive current is being measured on an odd-numbered range.
Replace C4.
Only when negative current is being measured on an odd-numbered range.
Replace C31.
Only when positive current is being measured on an even-numbered range.
Replace C2 and C5.
Only when negative current is being measured on an even-numbered range.
Replace C29 and C32.
Noto 1: Positive current means current which flows out from SMU.
2: Range number is as given pelow:
#1 100mA Range
#2 10mA Range
#3 1mA Range
#4 100µA Range
#5 10µA Range
#6 1µA Range
#7 100nA Range
#8 10nA Range
#9 1nA Range



Note: Set the SMU output to 0V, +100V and -100V. Two seconds after each output is set, measure the voltage at TP2. If the measured voltages satisfy the following equations, the CMRR is OK.

$$|V_1 - V_0| \leq 20\text{mV}$$

$$|V_2 - V_0| \leq 20\text{mV}$$

where V_0: Voltage at TP2, 2 seconds after 0V is set.
V_1: Voltage at TP2, 2 seconds after 100V is set.
V_2: Voltage at TP2, 2 seconds after -100V is set.

Note: Range number is as given below:

#1	100mA	Range
#2	10mA	Range
#3	1mA	Range
#4	100μA	Range
#5	10μA	Range
#6	1μA	Range
#7	100nA	Range
#8	10nA	Range
#9	1nA	Range

A5 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 2 of 9).

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 3 of 9).

Flow Diagram (A5 – 2)

START

(SMU Status Error 1)

Unless otherwise indicated, waveforms are those observed during the Self-Test sequence for Error 1. Execute the self-test on the "DIAGNOSTICS" page and refer to Fig. 8-36.

- Is the waveform at TP11 less than 20Vp-p?
  - NO → Connect TP8 to TP9. After this, Self-Test is not necessary. Use a DVM to check the voltages. Unless otherwise indicated, refference is TP9. → Check the voltages at L1, L2, L3, CR10 and CR14. Refer to Fig. D. → Are all voltages correct?
    - NO → Check L1, L2, L3 CR10 and CR14.
    - YES → Is the voltage at TP10 0V±1V?
      - NO → Check the voltages at J1. See Fig. E. → Are the ±130V and ±4V correct?
        - YES → Check the power amplifier circuit.
        - NO → Go to Flow Diagram (A13).
      - YES → Is the voltage at TP2 0V±0.1V?
        - NO → Is the voltage between TP11 and 13 0V±0.1V?
          - YES → Check U4 and R60.
          - NO → Check the voltages at J1. See Fig. E. → Are the +15V and -17V correct? Also, are the voltages across CR66 and CR63 correct?
            - NO → Check L4 and L5.
            - YES → Check the logic levels at the following points. Reference is TP10. H: -17V, L: 0V → Are all correct?
              - NO → Check U16, U17, Q23, Q24, Q25, Q27 and Q29.
              - YES → Is the voltage at TP13 0V±10mV? Reference is TP10.
                - NO → Is the voltage at TP10 0V±5mV? Reference is TP10.
                  - YES → Check U13.
                  - NO → Check U14 and current leakage.
                - YES → Is the voltage at TP12 0V±100mV? Reference is TP10.
                  - YES → No error. Return to Flow Diagram (A5-1).
                  - NO → Check U12, U24 and Q27.
        - YES → Are the voltages at TP1 and TP14 +10V ±0.2V and -10V±0.2V, respectively?
          - NO → Check U6.
          - YES → Is the voltage at TP3 +1.2V±0.2V?
            - NO → Check U1, CR4 and CR8.
            - YES → Is the voltage at TP4 -1.2V±0.2V?
              - NO → Check U3, CR35 and CR39.
              - YES → Is the voltage at TP7 0V±1.4V?
                - NO → Check U2, CR18 and CR19.
                - YES → Check Q4, Q5, Q2 and Q18.
  - YES → Is the waveform at TP14 correct?
    - NO → Check U6.
    - YES → Is the waveform at TP11 correct?
      - NO → (C)
      - YES → Observe the waveform at TP2. Are the portions enclosed in circles in Fig. F ±1V±0.2V and 0V±0.2V?
        - NO → Check K5, K6 and K7, and their drive circuits.
        - YES → Is the waveform at TP6 less than 20mVp-p?
          - NO → Check U5.
          - YES → Is the waveform at TP16 correct?
            - NO → Check the control Loop Detector circuit.
            - YES → Is TP15 LOW?
              - NO → Check the OSC. Detector circuit.
              - YES → Check U18.

U16		U17	
pin 4:	H	pin 4:	L
pin 5:	H	pin 5:	L
pin 7:	L	pin 6:	H
pin 12:	H	pin 7:	H
pin 13:	L	pin 12:	L
pin 14:	H	pin 13:	L
		pin 14:	H

(C) → Is there oscillation in the waveform at TP11?
- YES → Check C5 and C11.
- NO → Is the waveform at TP11 as shown in Fig. G?
  - NO → Is the waveform at TP5 correct?
    - YES → Check U2.
    - NO → Check U5.
  - YES → Is the waveform at TP2 correct?
    - NO → Check K5 and the drive circuit.
    - YES → Is the waveform at TP3 as shown in Fig. H?
      - NO → Is the waveform at TP14 correct?
        - YES → Check U1.
        - NO → Check Iin Filter Amp. and U16.
      - YES → Is the voltage at the collector of Q1 0V?
        - YES → Check Q1 and Q17.
        - NO → Check CR6 and Q2.

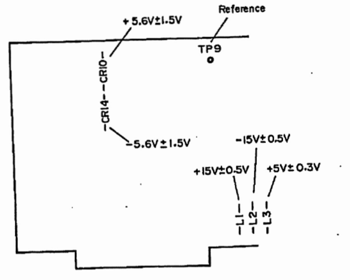


Figure D

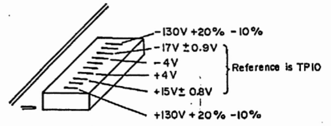


Figure E

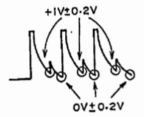


Figure F

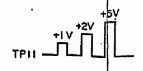


Figure G

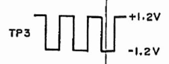


Figure H

Flow Diagram (A5 - 3)

START

(SMU Status Error 2)

Unless otherwise indicated waveforms are those observed during the Self-Test sequence for Error 2. Execute the self-test on the "DIAGNOSTICS" page and refer to Fig. 8-36.

Is the waveform at TP2 correct during the Self-Test sequence for Error 1?
- YES → Observe the waveform at U9 pin 12 and the emitter of A3Q5. Check when the pulse is appears at A3Q5 (E). Refer to Fig. I. → Does the pulse appear at either 30 or 31?
- NO → The following checks must be made with Self-Test off and the SMU idle.

Is the voltage at the gate of Q26 -17V? Reference is TP10.
- YES → Is the voltage at the gate of Q25 -17V? Reference is TP10.
  - YES → Check Q26, Q28 and Q25.
  - NO → Check U17.
- NO → Is the voltage at U19 pin 1 -17V? Reference is TP10.
  - YES → Is the voltage at emitter of Q33 0V±0.3V? Reference is TP10.
    - YES → Check CR65.
    - NO → Check Q33.
  - NO → Is the voltage at U19 pin 2 +9.4V±0.1V? Reference is TP10.
    - YES → Check U18, U19 and the U19 drive circuit.
    - NO → Check CR66.

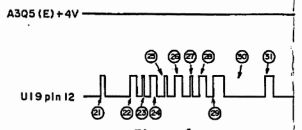
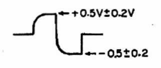


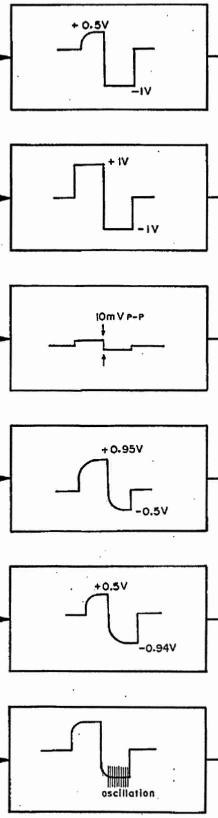
Figure 1

Does the pulse appear at either 30 or 31?
- YES → Is the waveform at TP11 correct?
  - YES → Is the waveform at TP16 correct?
    - YES → Check U10.
    - NO → Check U7 and CR52.
  - NO → Which waveform is observed at TP11 during the self-test sequence for Error 2?
- NO → Is the voltage at TP2 0V±100mV? Reference is TP9.
  - YES → Does the pulse appear at 22?
    - YES → Check Q23, K6, K7 and their drive circuits.
    - NO → Does the pulse appear at either 23 or 24?
      - YES → Check Q32, K7 and their drive circuits.
      - NO → Does the pulse appear at either 25 or 26?
        - YES → Check the drive circuit for Q31.
        - NO → Does the pulse appear at either 27 or 28?
          - YES → Check Q29 and its drive circuit.
          - NO → Check Q25 and its drive circuit.
  - NO → Is the voltage at TP12 0V±60mV? Reference is TP13.
    - YES → Check U4.
    - NO → Is the voltage at TP11 0V±5mV? Reference is TP10.
      - YES → Check U12 and U13.
      - NO → Is the voltage at U14 pin 3 0V±2mV? Reference is TP11.
        - YES → Check Q25, Q26, Q28, Q29 and Q30 for leakage.
        - NO → Check U14.

The correct waveform is shown below:



Which waveform is observed at TP11 during the self-test sequence for Error 2?



- +0.5V / -1V → Check U3, CR35, CR39, CR37 and Q18.
- +1V / -1V → Check Q23, Q30, Q29 and their drive circuits.
- 10mV P-P → Check Q31, K6 and their drive circuits.
- +0.95V / -0.5V → Check CR3 and CR7.
- +0.5V / -0.94V → Check CR34 and CR38.
- oscillation → Check Q19 and Q31.
- Correct waveform but incorrect peak voltages. → Check U1 and U3.

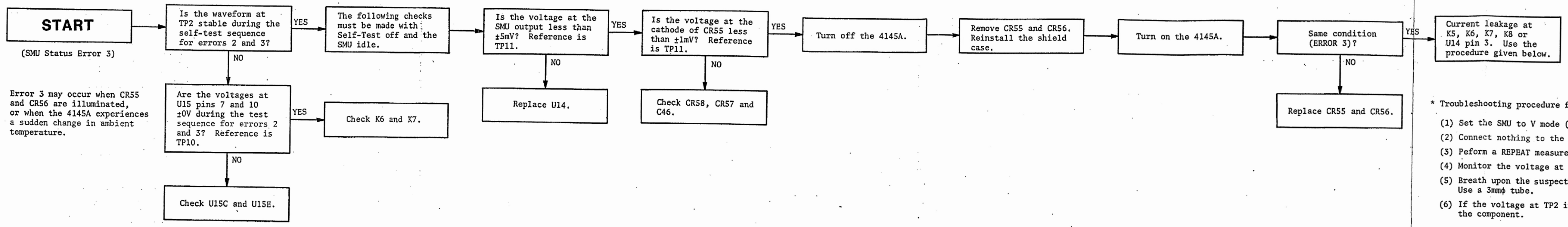
A5 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 4 of 9).

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 5 of 9).

Flow Diagram (A5 - 4)



Note: Error 3 may occur when CR55 and CR56 are illuminated, or when the 4145A experiences a sudden change in ambient temperature.

* Troubleshooting procedure for leakage current.

(1) Set the SMU to V mode (I measurement).

(2) Connect nothing to the SMU's output (open).

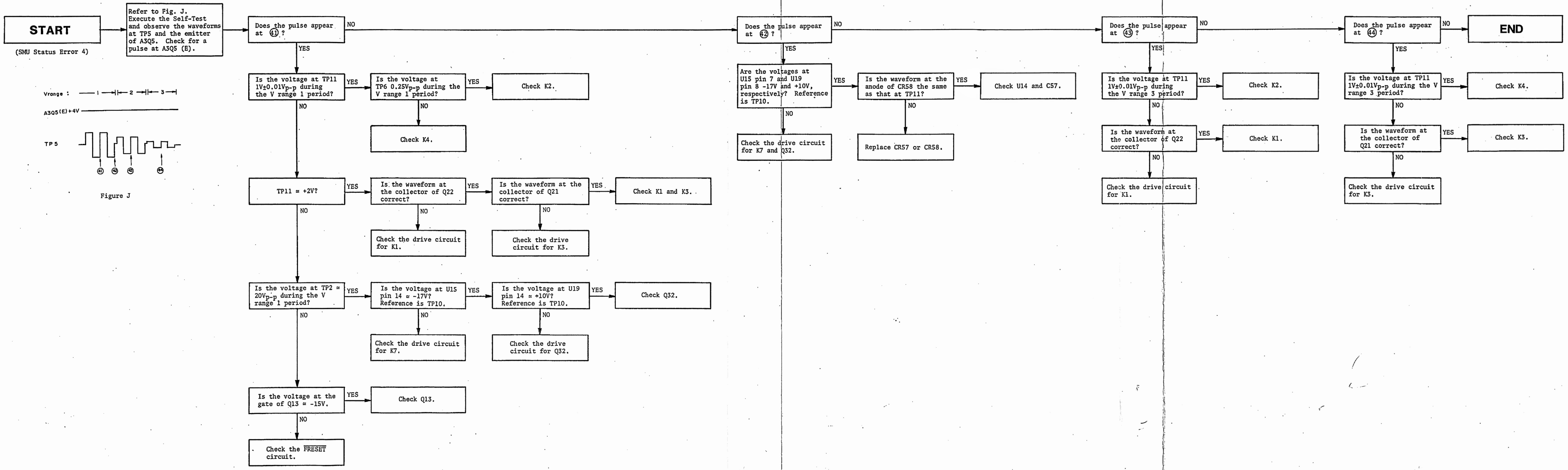
(3) Peform a REPEAT measurement.

(4) Monitor the voltage at TP2.

(5) Breath upon the suspected component. Use a 3mmϕ tube.

(6) If the voltage at TP2 increases, replace the component.

Flow Diagram (A5 - 5)



A5 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 6 of 9).

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 7 of 9).

Flow Diagram (A5 - 6)

START

(SMU Status Error 5)

Refer to Fig. K. Execute the Self-Test and observe the waveforms at TP5 and the emitter of A3Q5. Check for a pulse at A3Q5 (E).

Does the pulse appear at (51) ?
- YES → Is the waveform at TP2 correct?
  - YES → Check U14, C45 and R121.
  - NO → Remove CR57. → Same condition?
    - YES → Check U14 and the drive circuits for K7 and Q32.
    - NO → Replace CR57 or CR58.
- NO → Does the pulse appear at (52) ?
  - YES → Check Q31, R135, C54 and C47.
  - NO → Does the pulse appear at (53) .
    - YES → Check Q30 and its drive circuit.
    - NO → Check U4 and U12 for noise.

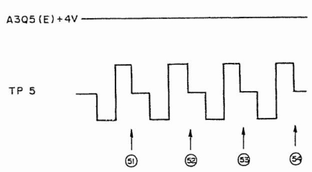
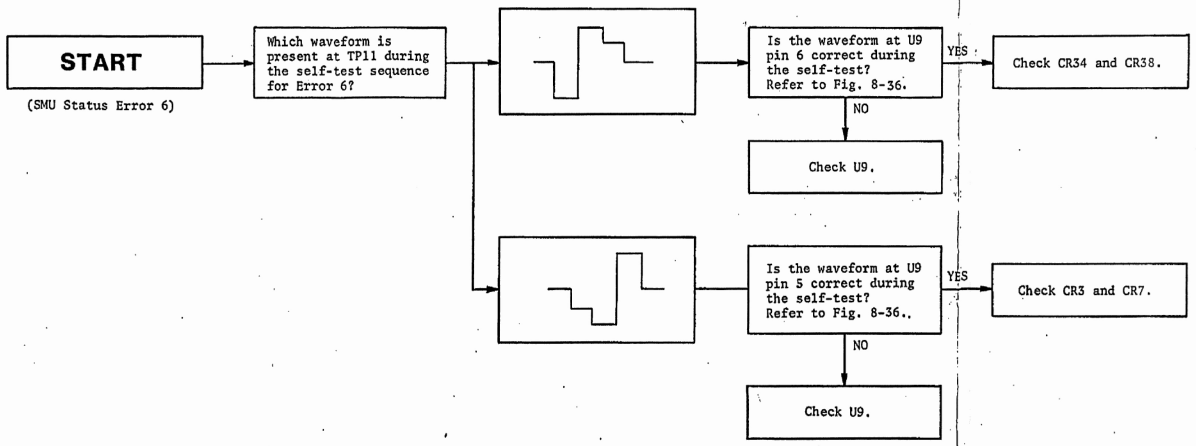
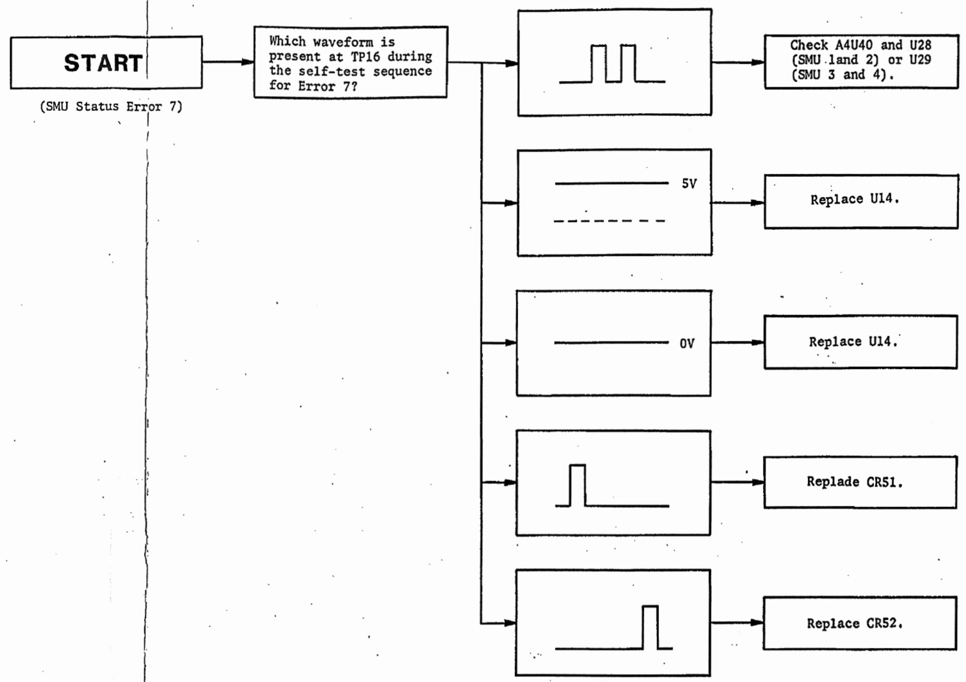


Figure K

Flow Diagram (A5 - 7)



Flow Diagram (A5 - 8)



A5 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 8 of 9).

Figure 8-35. A5 Board Troubleshooting Flow Diagram (Sheet 9 of 9).

SMU Self-Test Waveforms

The waveforms shown in this figure will appear at the indicated SMU test points when Self-Test is executed. Each time a flow diagram instructs you to check the waveform at a certain test point, connect the oscilloscope to the indicated test point, start the self-test by pressing the Self-Test softkey on the DIAGNOSTICS page (refer to Figure 3-32), and compare the displayed waveform with the corresponding waveform given here.

Self-Test is divided into two parts. The first part checks the SMU controller and the second part checks the SMUs one at a time, starting with SMU1. Thus, if you are troubleshooting SMU4, the last SMU tested, the waveforms shown in this figure will not appear until about seven or eight seconds after Self-Test is executed. The Self-Test for one SMU lasts about two seconds and is divided into six steps, each related to one or two of the seven possible SMU status error codes (refer to "SMU Status" in Table 8-2). Also, because the SMU Self-Test is slow and non-repetitive, a dual channel storage oscilloscope is required for making these measurements.

Control settings for the oscilloscope are as follows :

STORAGE	ON
AUTO/NORMAL	NORMAL
SINGLE	ON
TIME/DIV	.2 sec/div
VOLTS/DIV	.5V/div (for 10:1 probe)
TRIGGER	EXT, POSITIVE (TP17)*
TRIGGER LEVEL	POSITIVE

* Trigger signal is taken from TP17 of the SMU being checked.

Figure 8- 36. SMU Self-Test Waveforms.

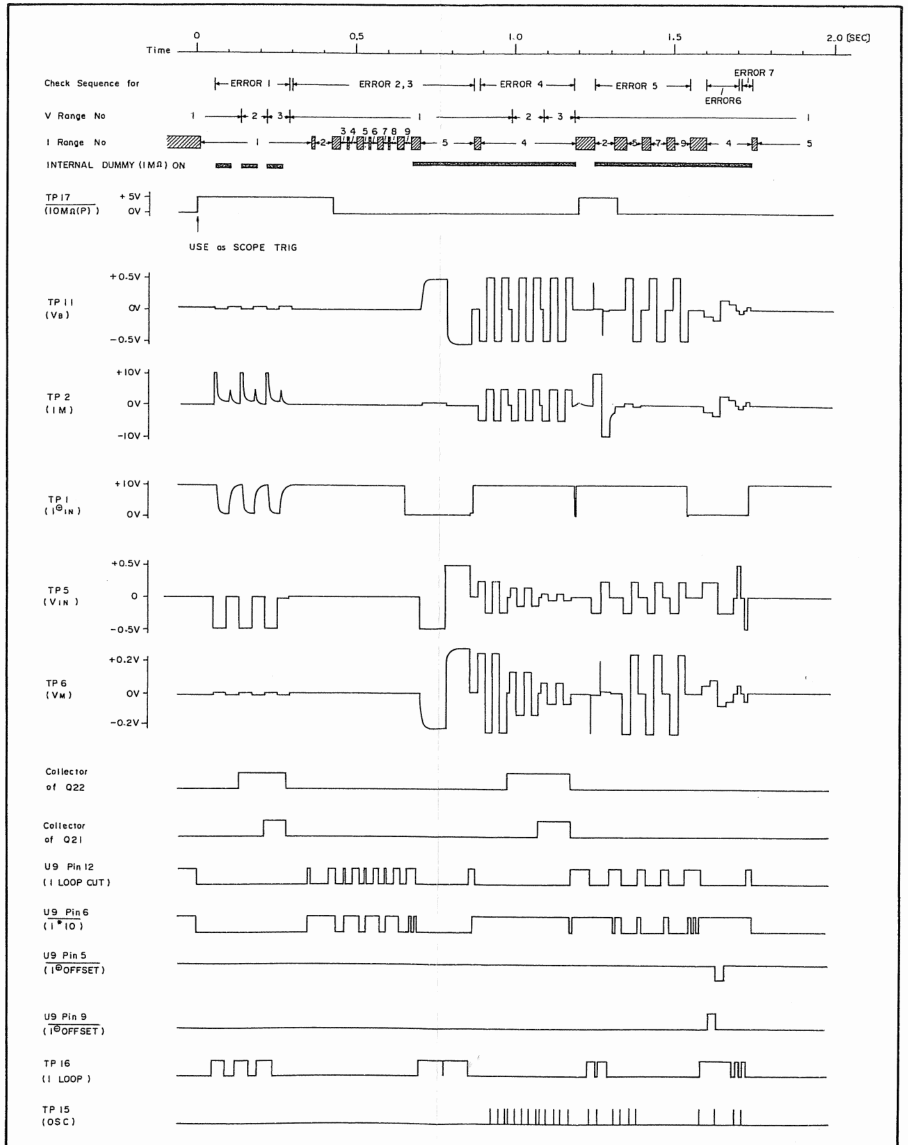


Figure 8- 36. SMU Self-Test Waveforms.

8-44. A5 SMU BOARD

8-45. Theory of operation of the SMUs is described in the following paragraphs. An overall block diagram is shown in Figure 8-37.

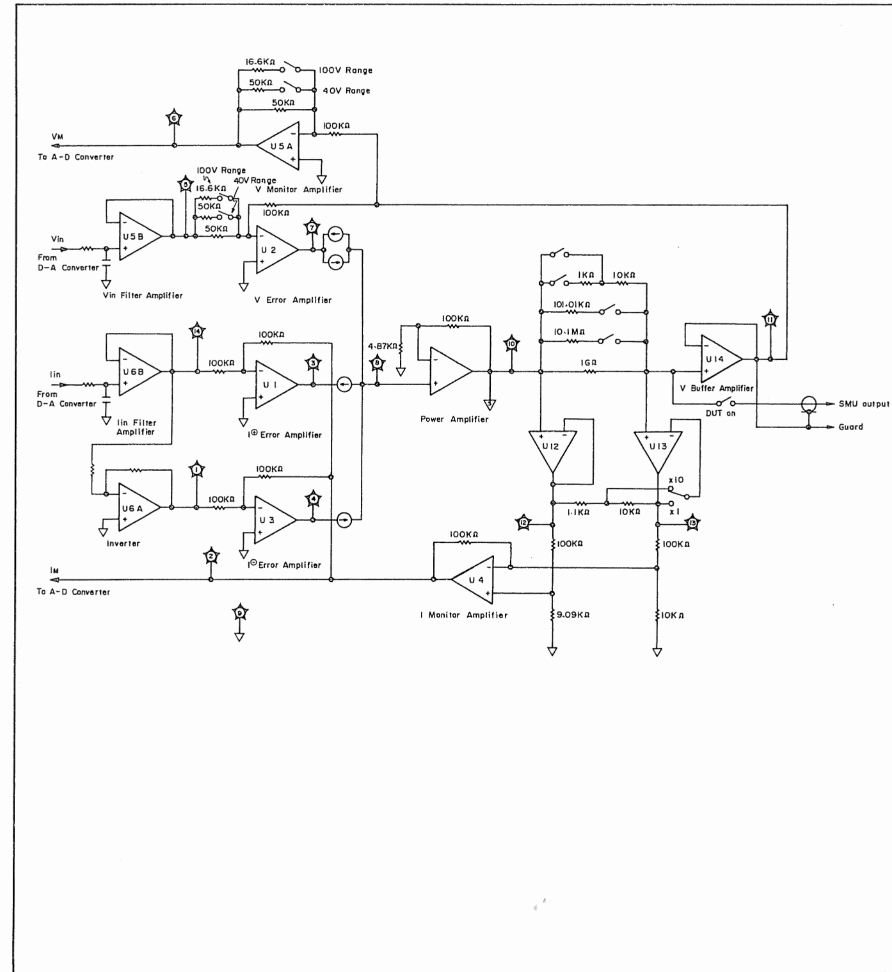


Figure 8-37. SMU Board Block Diagram.

Each SMU has two modes of operation: V mode (voltage source/current monitor) and I mode (current source/voltage monitor). The equivalent circuits for each mode are shown in Figures 8-38 and 8-39, respectively. V mode operation will be described first.

Output voltage, Vout, is determined by Vref, R_1, and R_2, and can be calculated by first noting that, because negative feed-back is employed, the inverting input of the Error Amplifier is at virtual ground. Hence, the voltage at the inverting terminal is calculated as

$$\frac{Vref}{R_1} + \frac{Vout}{R_2} = 0 \;\cdots\cdots\; (8\text{-}1)$$

Solving for Vout, we have

$$Vout = -\frac{R_2}{R_1}\cdot Vref \;\cdots\cdots\; (8\text{-}2)$$

Also, the current output from the SMU can be obtained by measuring the voltage drop across the range resistor Rr. If the gain of the Differencial Amplifier is 1, output current Iout is simply calculated from the differencial amplifier's output voltage I_M and the value of Rr as

$$Iout = \frac{I_M}{Rr} \;\cdots\cdots\; (8\text{-}3)$$

Figure 8-39 shows SMU operation in I mode (Current output/Voltage monitor). Output current is determined by R_1, R_2, Rr and Vref as

$$Iout = -\frac{R_2}{R_1}\cdot\frac{Vref}{Rr} \;\cdots\cdots\; (8\text{-}4)$$

Also, the output voltage obtained from the V Buffer output is

$$Vout = V_M \;\cdots\cdots\; (8\text{-}5)$$

In the actual circuit, these two modes of operation are implemented by one circuit.

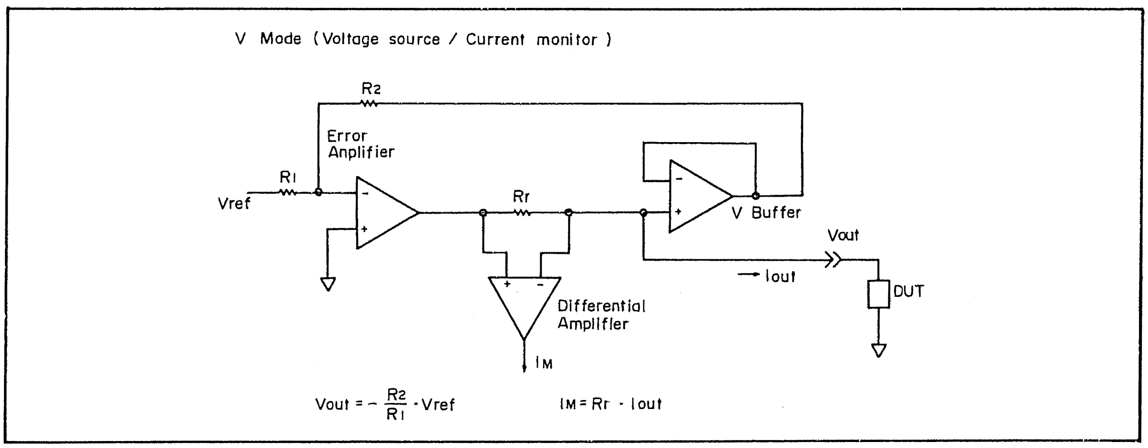


Figure 8-38. SMU V Mode Operation.

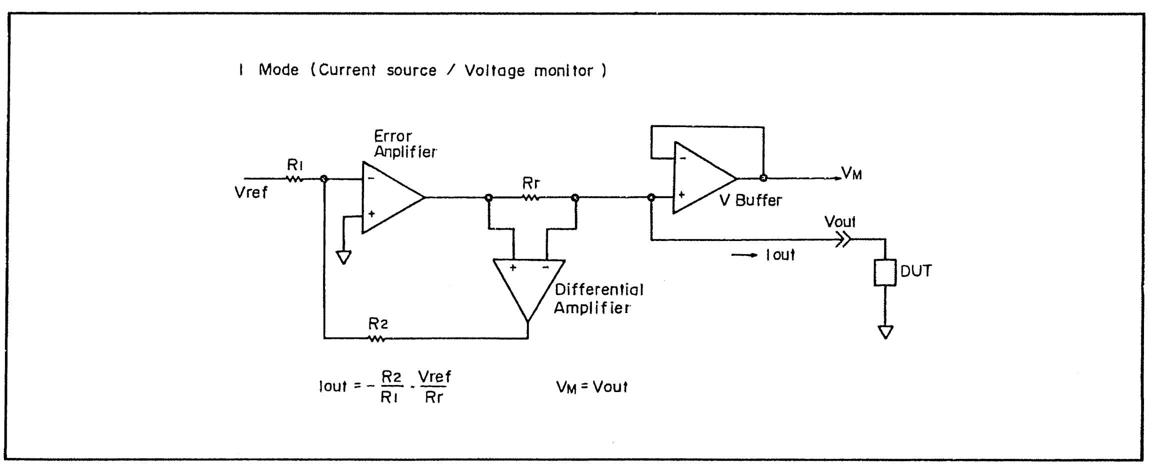


Figure 8-39. SMU I Mode Operation.

[Error Amplifiers]

As shown in Figure 8-37, there are three error amplifiers: V, I⊕, and I⊖. Input reference voltages are applied to the error amplifiers through the filter amplifiers. The input reference voltage for the I⊖ error amplifier is inverted. Two input reference voltages, Vin and Iin, are applied at all times. One specifies the SMU output value and the other specifies the compliance value. Vin is from -10 volts to +10 volts depending on the programmed output. Also, Iin is from 0 to -10 volts.

Assume that a resistive load is connected to the SMU in V Mode (voltage output/current measurement). If a voltage sweep and current measurement is made, and if the resistance of the load is not so high, measurement results displayed on the CRT will be as shown in Figure 8-40. Output current is limited by positive and negative compliance. Normally, output voltage is controlled by the V error amplifier. However, when the output current reaches positive or negative compliance, the corresponding I⊕error or I⊖error amplifier controls the output current.

Also, in I Mode (current output/voltage monitor), I⊕error amplifier controls positive current (flow out) and I⊖error amplifier controls negative current (flow in). The V error amplifier specifies the voltage compliance value. These conditions are called (1) V control mode, (2) I⊕control mode, and (3) I⊖control mode.

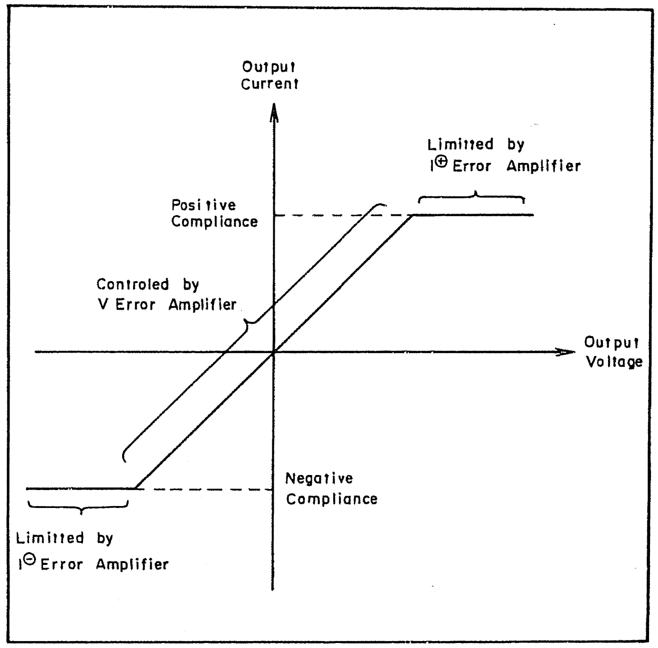


Figure 8-40. Current Compliance in V Mode.

One of the three error amplifiers—U1, U2 and U3 in the actual schematic—controls the SMU output. Figure 8-41 shows the V error amplifier and a simplified drawing of its output circuitry. The voltage at point Ⓐ in the figure changes according to the input reference voltage.

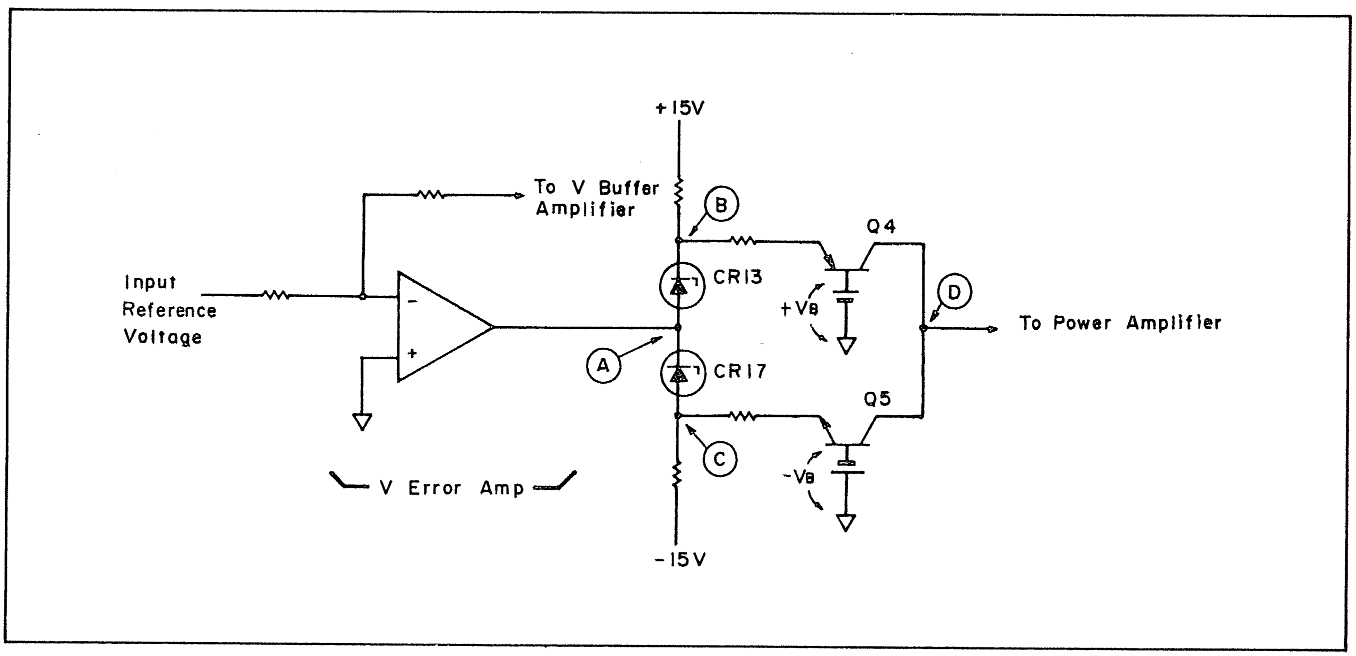


Figure 8-41. V Error Amplifier.

Assume that the voltage at point Ⓐ is initially zero. The voltages at points Ⓑ and Ⓒ, then, are of the same magnitude but with opposite polarities.

The voltage at point Ⓑ is slightly higher than $+V_B$. This forward biases the emitter-base junction of Q4, allowing current to flow out from Q4. Similarly, the voltage at point Ⓒ forward biases Q5, allowing current to flow into Q5. If the voltage at point Ⓐ increases, the voltage at point Ⓑ will increase and the voltage at point Ⓒ will decrease, causing more current to flow out of Q4 and less current to flow into Q5.

Finally, the current flows into the Power Amplifier from point Ⓓ. If the voltage at point Ⓐ decreases, however, the current flows in the opposite direction.

The $I^{\oplus}$and $I^{\ominus}$ error amplifiers also have circuitry much like this. The $I^{\oplus}$ error amplifier, however, doesn't have CR13 and Q4, and the $I^{\ominus}$ amplifier doesn't have CR17 and Q5. This means that the $I^{\oplus}$ error amplifier can only sink current and the $I^{\ominus}$ error amplifier can only source current.

The outputs from the three error amplifiers are all tied directly to the noninverting input of the power amplifier.

As described earlier, the SMU is in one of three conditions—(1) V control mode, (2) $I^{\oplus}$ control mode, or (3) $I^{\ominus}$ control mode—depending on which error amplifier is controlling the output.

(1) V control mode:

Figure 8-42 (a) shows the V control mode. Output voltage from V error amplifier is approximately zero, and idle current flows from I_1 to I_2.

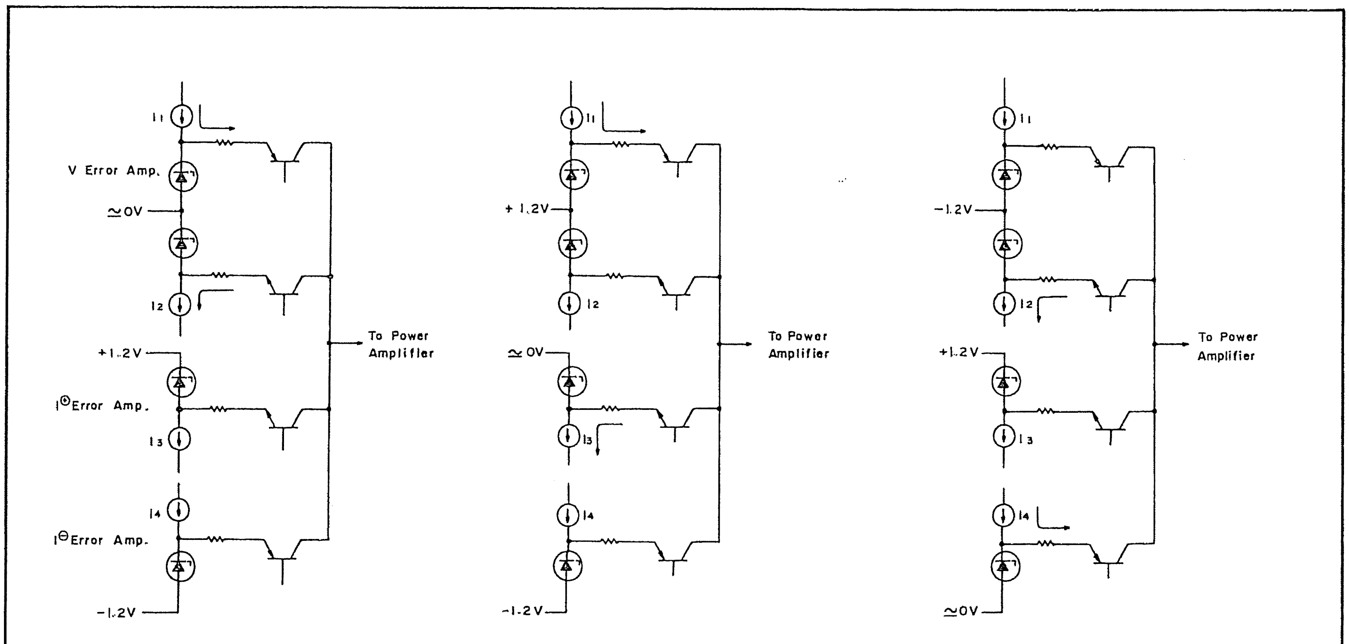
On the other hand, the $I^{\oplus}$ Error amplifier and the $I^{\ominus}$ Error Amplifier output no current because their input voltages are not zero.

(2) $I^{\oplus}$ control mode:

Figure 8-42 (b) shows $I^{\oplus}$ control mode. Output voltage from $I^{\oplus}$ error amplifier is approximately zero, and idle current flows from I_1 to I_3.

(3) $I^{\ominus}$ control mode:

Figure 8-42 (c) shows $I^{\ominus}$ control mode. Output voltage from $I^{\ominus}$ error amplifier is approximately zero, and idle current flows from I_4 to I_2.



(a) V control mode (b) $I^{\oplus}$ control mode (c) $I^{\ominus}$control mode

Figure 8-42. Three Control Modes.

When the error amplifier is not controlling power amplifier output, the voltage at its noninverting input is not zero.

The error amplifier will be saturated and output will increase up to the positive or negative voltage supply. In this condition, it is difficult to recover to the normal condition quickly. To prevent this, a feed-back loop with diodes is used. Figure 8-43 shows an example of diode dc feed-back.

Output voltage is held constant at the voltage drop caused by two diodes (approximately +1.2V or -1.2V).

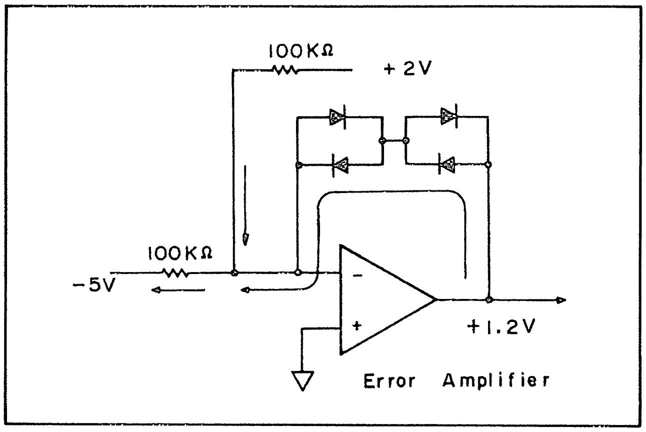


Figure 8-43. Example of Diode Feedback.

[Control Loop Detector]

The control loop detector, U7, detects which error amplifier is controlling the output. It also informs the SMU controller of compliance, causing an error message to be displayed. The input is connected to, TP7, output of the V error amplifier.

If the V error amplifier controls the output, TP7 is approximately zero, and both U7A and U7B are off, forcing $\overline{\mathrm{I}^{\oplus}\ \mathrm{CONT}}$ and $\overline{\mathrm{I}^{\ominus}\ \mathrm{CONT}}$ HIGH. If the $\mathrm{I}^{\oplus}$ error amplifier controls the output, the V error amplifier is saturated and its output is held at approximately +1.2 volts. Positive voltage turns on U7B and $\overline{\mathrm{I}^{\oplus}\ \mathrm{CONT}}$ goes LOW. Conversely, if the $\mathrm{I}^{\ominus}$ error amplifier controls the output, U7A turns on, and $\overline{\mathrm{I}^{\ominus}\ \mathrm{CONT}}$ goes LOW. The base of U7E is connected to $\overline{\mathrm{I}^{\oplus}\ \mathrm{CONT}}$ and $\overline{\mathrm{I}^{\ominus}\ \mathrm{CONT}}$ lines through CR51 and CR52.

If either $\overline{\mathrm{I}^{\oplus}\ \mathrm{CONT}}$ or $\overline{\mathrm{I}^{\ominus}\ \mathrm{CONT}}$ goes LOW, the collector of U7E (connected to SLP) goes HIGH. The microprocessor monitors SMU status by monitoring these signals, and displays error messages if necessary.

[Power Amplifier]

The power amplifier is of the non-inverting type. The gain of this amplifier is determined by R28 and R39, and is approximately 21.5.

The input stage is a difference amplifier consisting of Q6 and Q7. Q15 is a constant current source. Base voltage for Q15 is obtained from the voltage drop across CR30.

Q8 converts the low voltage input signal into a high voltage signal. This is to transmit the output signal of Q7 (operated in low voltage) to Q9 (operated in high voltage) via the voltage drop across R31. CR24, CR25, CR28 and CR29 protect Q6 and Q7. CR20, R40 and CR30 provides bias voltage for Q10 and Q16. Q9 controls Q10 and Q16.

The output stage is a complementary-symmetry amplifier consisting of Q11 and Q12. The collectors of Q11 and Q12 are connected to the SMU Power Source Board and held constant at +4V and -4V, respectively, above and below TP10 (FLT.COMMON), as shown in Figure 8-44.

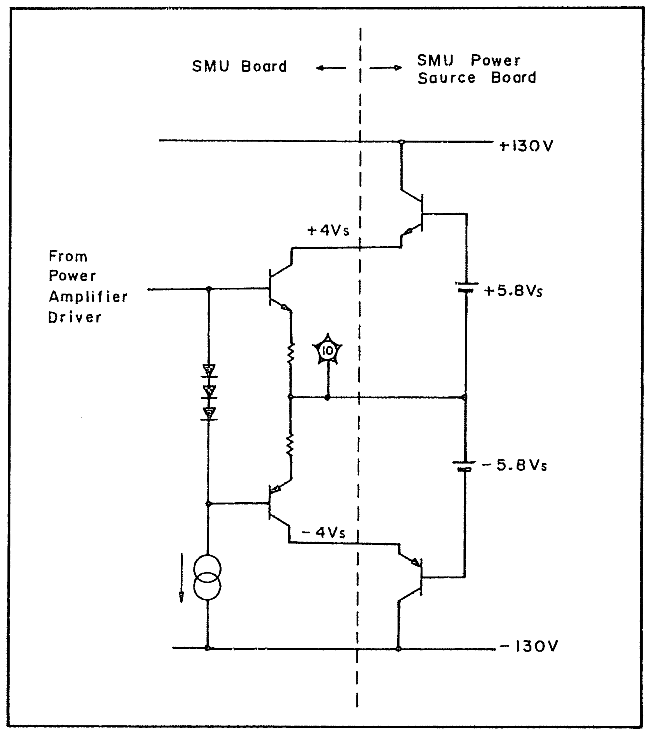


Figure 8-44. Power Amplifier Output Stage.

Since the SMU Power Source (A13 and A14) dissipates most of the power that is output from any one of the SMUs, Q11 and Q12 need not be high power devices.

CR21 and CR22 improve the transient response of Q11 and Q12.

[Reset Circuit]

Q14 drives Q13 to reset the power amplifier to prevent the SMU from outputting a spike when the 4145A is turned on or off. If the $\overline{FRESET}$ line goes to LOW, Q14 turns on and Q13 also turns on.

[Range Resistors]

Current measurement is made by measuring the voltage drop across the range resistor. As the resolution and dynamic range of A-D converter is specified, if various range resistors are used, various current ranges, from 1nA range to 100mA range, are provided. Also, the voltage drop across the range resistor is measured by the I monitor amplifier, which has a gain of X1 or X10.

Therefore, with a combination of five range resistors and two multipliers, ten current measurement ranges are possible. Only nine ranges, however, are used in the actual circuit. A simplified drawing of the range resistor circuit is shown in Figure 8-45, and the nine ranges are listed in Table 8-6.

As shown in Figure 8-46, ranging is performed by four FET switches driven by ramp waves. If these switches were turned on and off by a step function, a spike would appear at the SMU output because the voltage drop across the range resistor would change rapidly. To prevent this, the FET switches are turned on gradually. The ramp waves are generated by the ramp generator, U18 and U19. U19 functions as a constant current source and U18 is normally on.

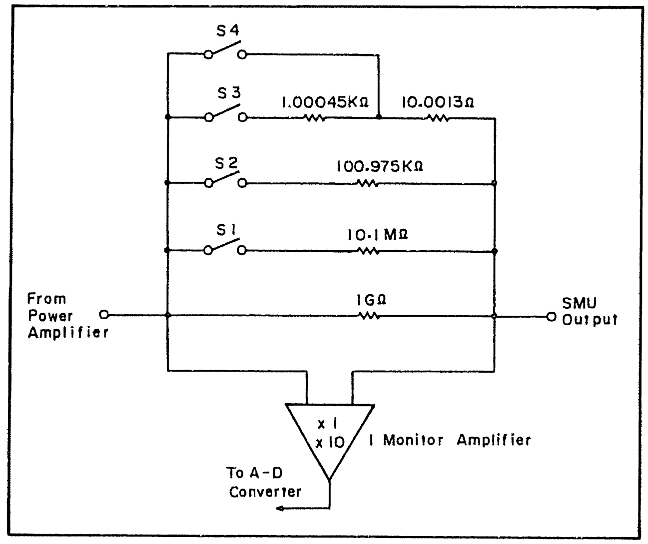


Figure 8-45. Range Resistors.

If U18 is turned off, U19 gradually charges the capacitor connected at the collector of U18.

Since the channel resistance of an FET switch is neither zero when on nor infinite when off, relays are used in conjunction with the FET switches for the 100kΩ and 10MΩ range resistors. Also, to minimize leakage current when the relay breaks, the relay is connected to guard. For the 10Ω and 1kΩ range resistors, additional FETs (Monitor Point Selector) are used to select the appropriate monitor point.

Table 8-6. Relationship between Current Ranges and Range Resistors

Range #	Full Scale	Resistance of Range Resistor	Gain of I Monitor Amplifier	S1 S2 S3 S4
1	100mA	10Ω	X10	on on on on
2	10mA	1kΩ	X1	on on on off
3	1mA		X10	
4	100μA	100kΩ	X1	on on off off
5	10μA		X10	
6	1μA	10MΩ	X1	on off off off
7	100nA		X10	
8	10nA	1GΩ	X1	off off off off
9	1nA		X10	

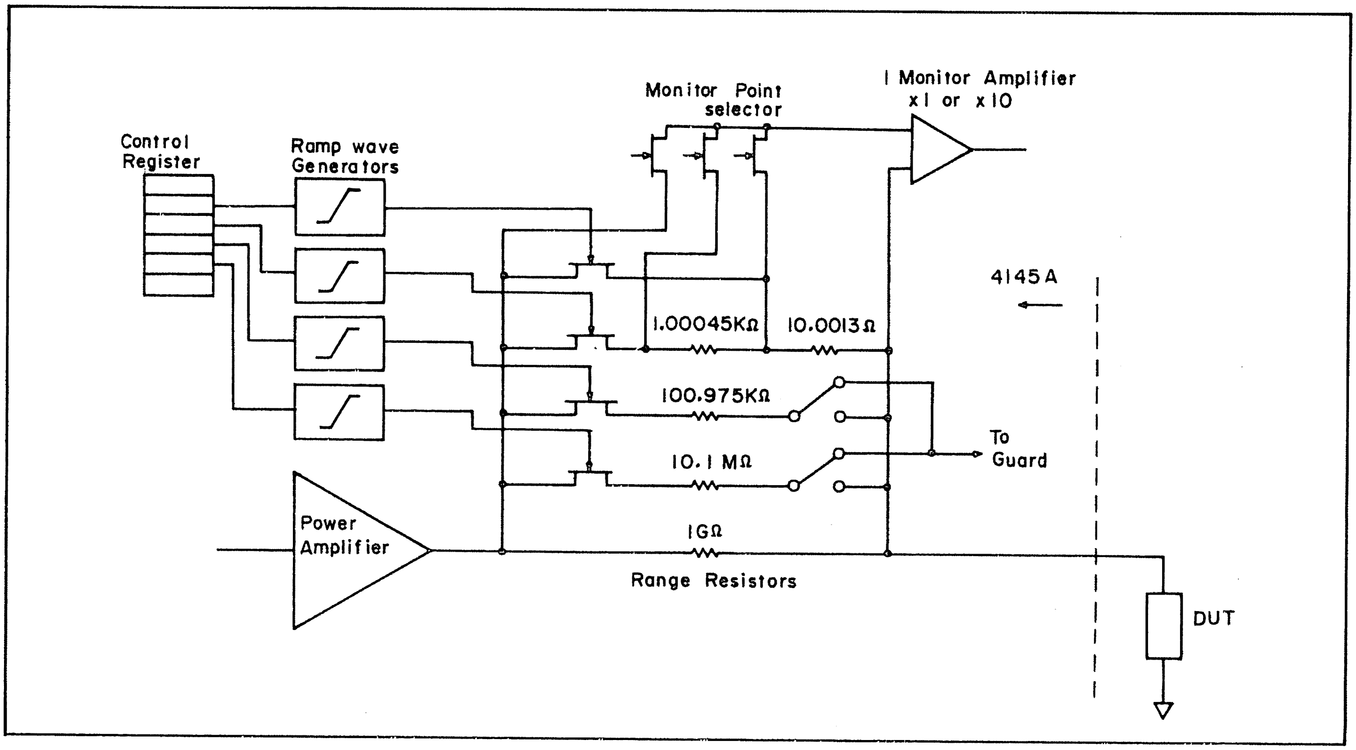


Figure 8-46. Range Resistor Circuit.

[Oscillation Detector]

If the SMU oscillates because of a reactive load, the Oscillation Detector detects it and sends the detection signal to the SMU controller. The detector monitors the output of the power amplifier, which is part of the SMU's feed-back loop, through the high-pass filter (C37 and R89). Oscillations, if they occur, are rectified and applied to the input of U8, whose output goes HIGH, informing the SMU controller that the SMU and device under test is oscillating.

CR49 and CR50 limit the input oscillation signal to 9Vp-p.

[V Monitor Amplifier]

The V Monitor Amplifier, U5A, is an inverting amplifier with three multipliers--X .5, X .25 and X .1--for the 20V, 40V and 100V ranges, respectively. The multipliers are determined by the ratio of input resistor R63 and feed-back resistors R64 through R66. Ranging is performed by K2 and K4 (Refer to Table 8-7.). The amplifier outputs an inverted 0 - ±10V, depending on the voltage at the V Buffer Amplifier's output, which is at the same voltage as the output voltage of the SMU.

Table 8-7. V Monitor Amplifier Ranging

Range	Multiplier	K2	K4
20V	X .5	OFF	OFF
40V	X .25	ON	OFF
100V	X .1	ON	ON

[I Monitor Amplifier]

The I Monitor Amplifier consists of a difference amplifier and two voltage followers. The two voltage followers output the voltage difference across the range resistor and have a combined gain of X1 or X10. (X10 effectively multiplies the value of the selected range resistor by ten.) When Q23 is on and Q24 is off, the voltage difference between the outputs of U12 and U13 is the same as the input. When Q23 is off and Q24 is on, however, the output is ten times the input. U4, with properly selected resistors R60, outputs the voltage difference to the A-D converter and to the input circuit ($I^{\oplus}$ and $I^{\ominus}$ Error Amps) for feed-back.

Also, to minimize the noise effects and leakage on R60, guarding is used.

[Auto Calibration]

Each SMU is automatically calibrated every five minutes by the SMU controller. The SMU controller connects a 1MΩ dummy load (R125 to the SMU by activating K5. It then provides a known reference to the input of the error amplifiers and measures the SMU output on all ranges. Differences between the expected and measured values are stored in memory and used to compensate subsequent measurements.

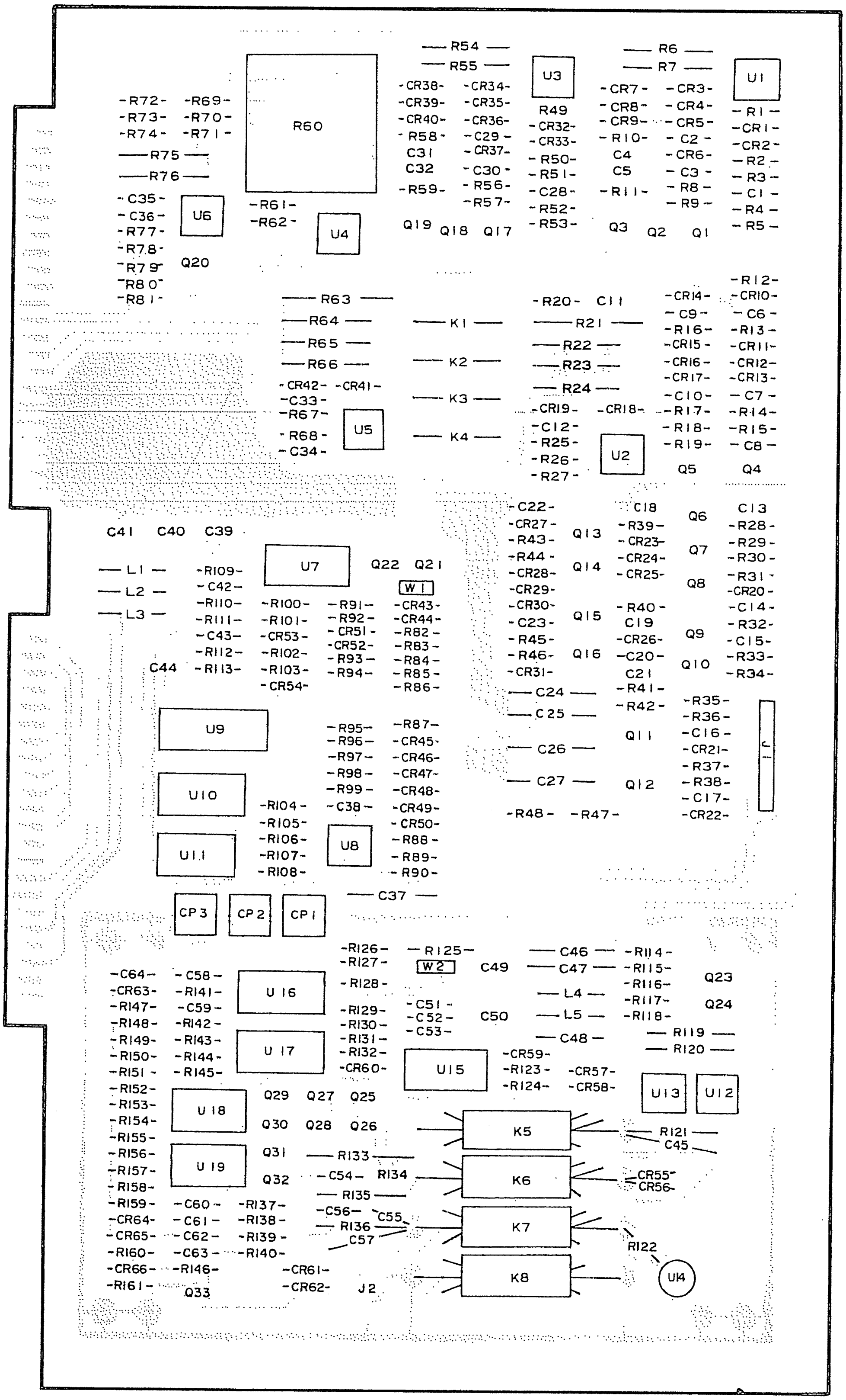
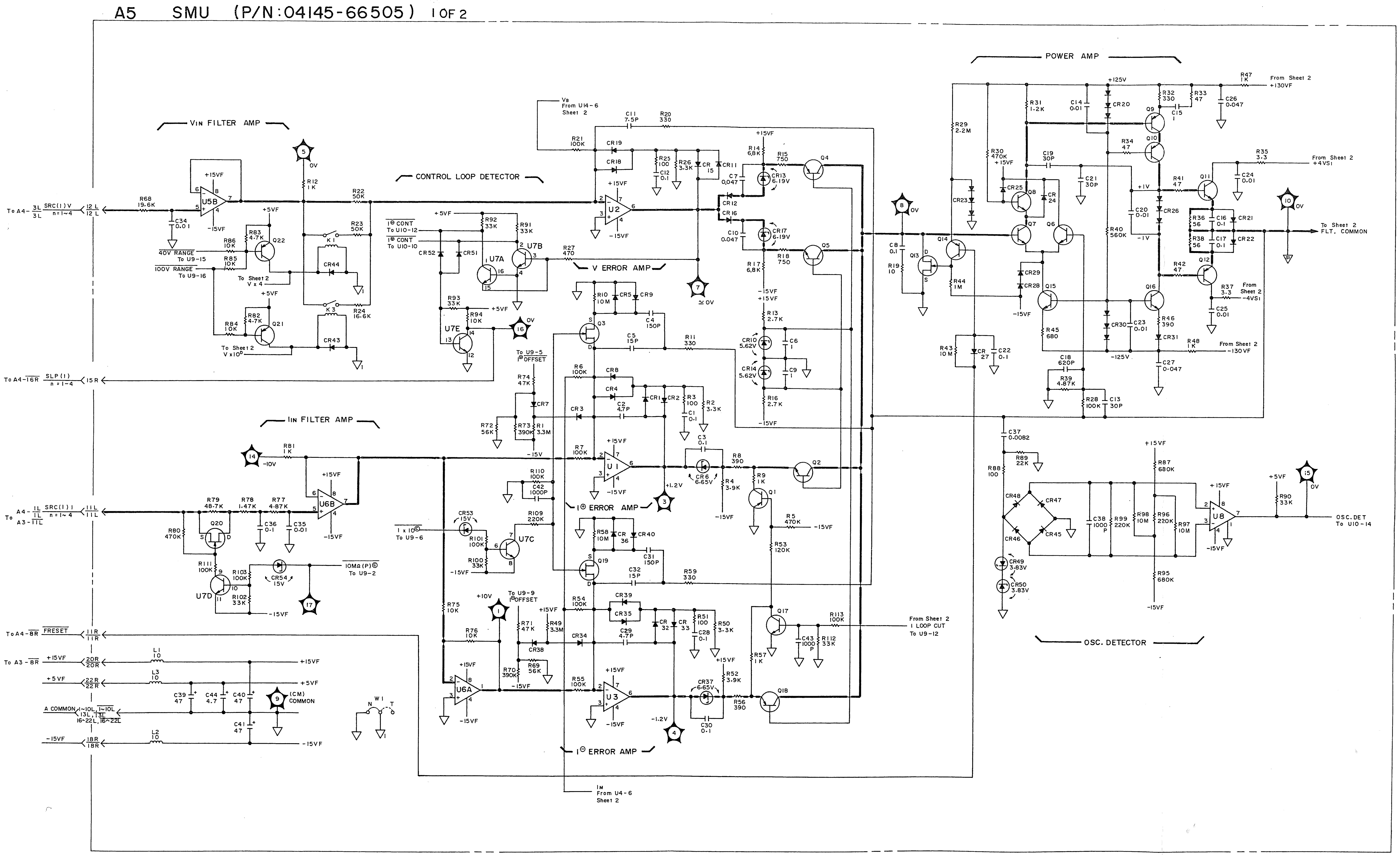


Figure 8-47. A5 SMU Board Assembly Component Locations.



FLOATING SECTION ANALOG GROUND (SAME AS COM)

ANALOG GROUND FOR TESTING

SMU COMMON

SMU COMMON FOR TESTING

NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSE ABBREVIATED. PREFIX ABBREVIATION WITH NUMBER FOR COMPLETE REFERENCE DESIGNAT

2. UNLESS OTHERWISE INDICATED:

   RESISTANCE IN OHMS (Ω)
   CAPACITANCE IN MICROFARADS (μF)
   INDUCTANCE IN MICROHENRIES (μH)

A5 BOARD

Figure 8-48. A5 SMU Board Assembly Schematic Diagram (Sheet 1 of 2).

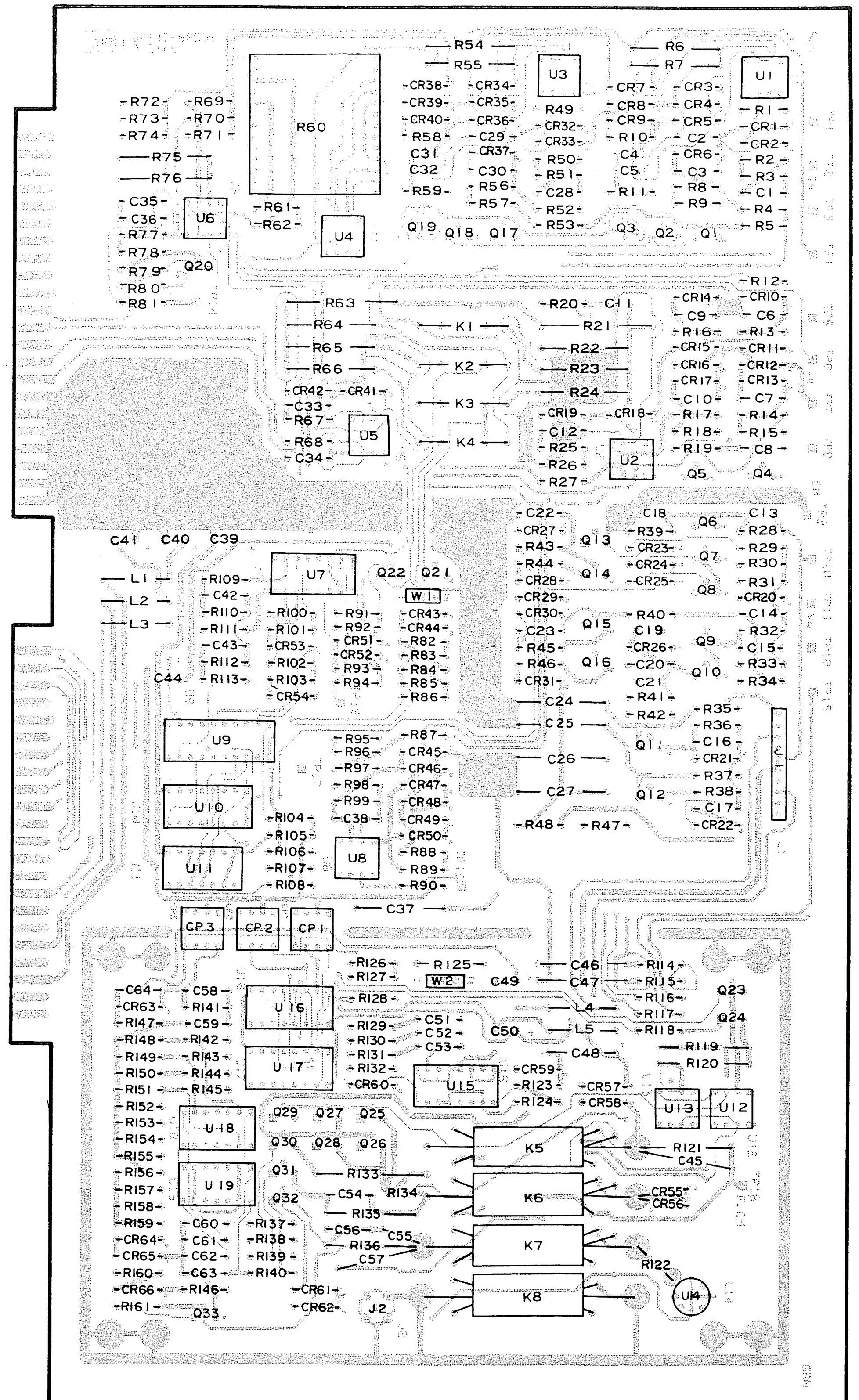
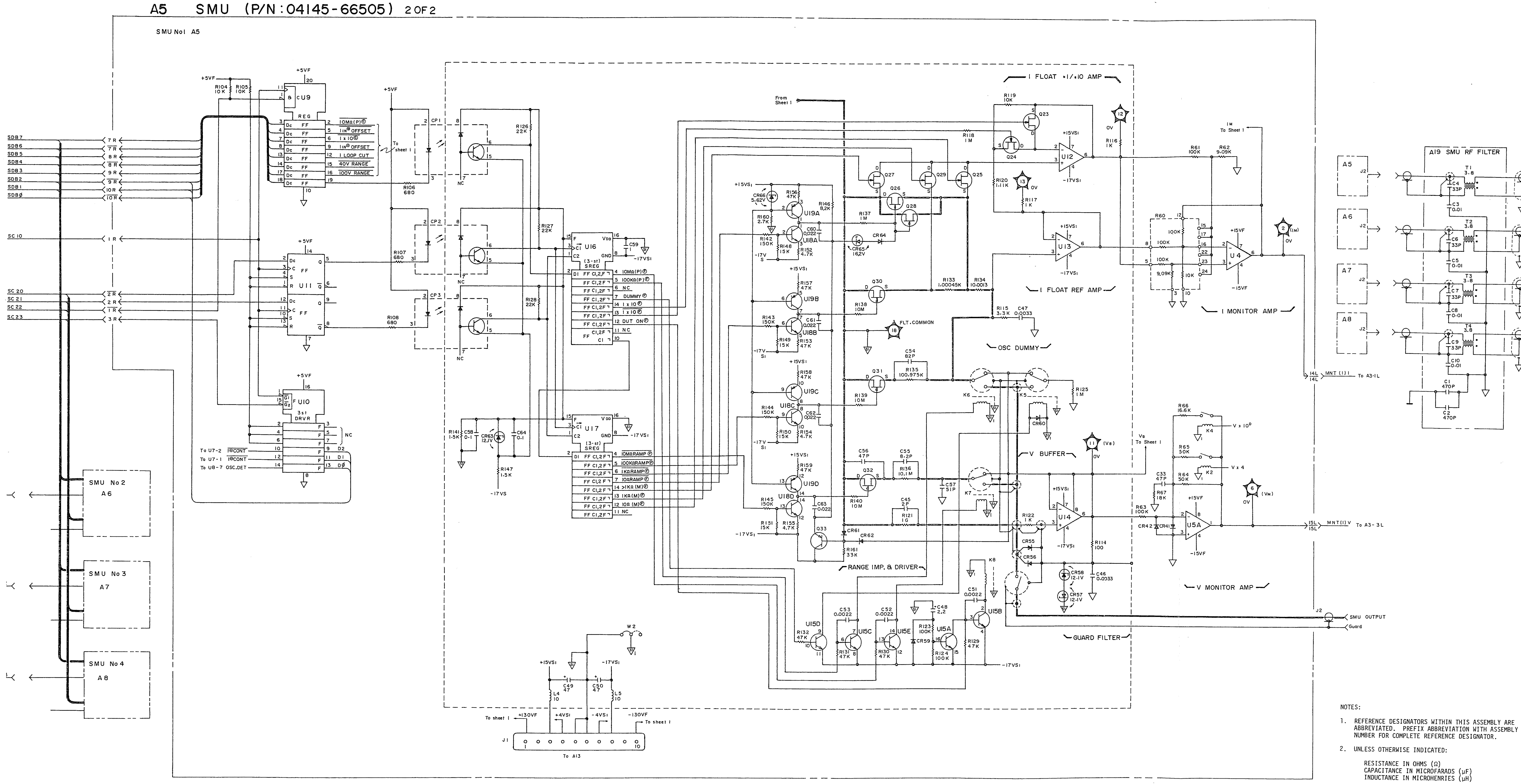


Figure 8-47. A5 SMU Board Assembly Component Locations.

A5 SMU (P/N:04145-66505) 2 OF 2



NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
2. UNLESS OTHERWISE INDICATED:

RESISTANCE IN OHMS (Ω)
CAPACITANCE IN MICROFARADS (μF)
INDUCTANCE IN MICROHENRIES (μH)

A5 BOARD

Figure 8-48. A5 SMU Board Assembly Schematic Diagram (Sheet 2 of 2).

8-46. A9 HP-IB AND MSU CONTROL BOARD

8-47. The A9 Board consists of two sections: the HP-IB control section and the MSU (Mass Storage Unit: FDD and Disc) control section.

[HP-IB Control Section]

All HP-IB interface functions are handled by the U7 HP-IB Interface Adapter. The Interface Adapter controls the "handshake" between the microprocessor and external HP-IB equipment connected to the 4145A.

[MSU Control Section]

U3 controls the FDD (Flexible Disc Drive) through the open-collector drivers. It also performs parallel-to-serial and serial-to-parallel data conversion for the FDD's serial read/write operation. Main control lines are described below:

$\overline{\text{FDCCS}}$ (FDC Chip Select):
Chip select signal for U3.

FDSEL (FDD Select):
Drive select and motor-on signal.

BCTRL ϕ, BCTRL 1:
Test use only.

DRIVE SELECT 1:
Drive select signal.

MOTOR ON:
Turn-on signal for the drive motor. Drive motor is on when this line is set to "LOW."

STEP:
Drive signal for the step motor.

DIRECTION IN:
Determines step direction for the step motor. Motor steps in toward the center of the disc when this line is set to "LOW."

HEAD LOAD:
Engages the R/W Head.

WRITE GATE:
Enables the write gate on the FDD when data is sent to FDD.

WRITE DATA:
Frequency-modulated data is serially sent to the FDD.

READY:
FDD ready signal. When a disc is inserted and the drive is turning, this line is set to "LOW."

INDEX:
Index hole detection signal.

TRACK ϕϕ:
Indicates that the R/W Head is on the outermost track (track 0).

WRITE PROTECT
Detects write-protected discs.

READ DATA
Data signal sent from FDD.

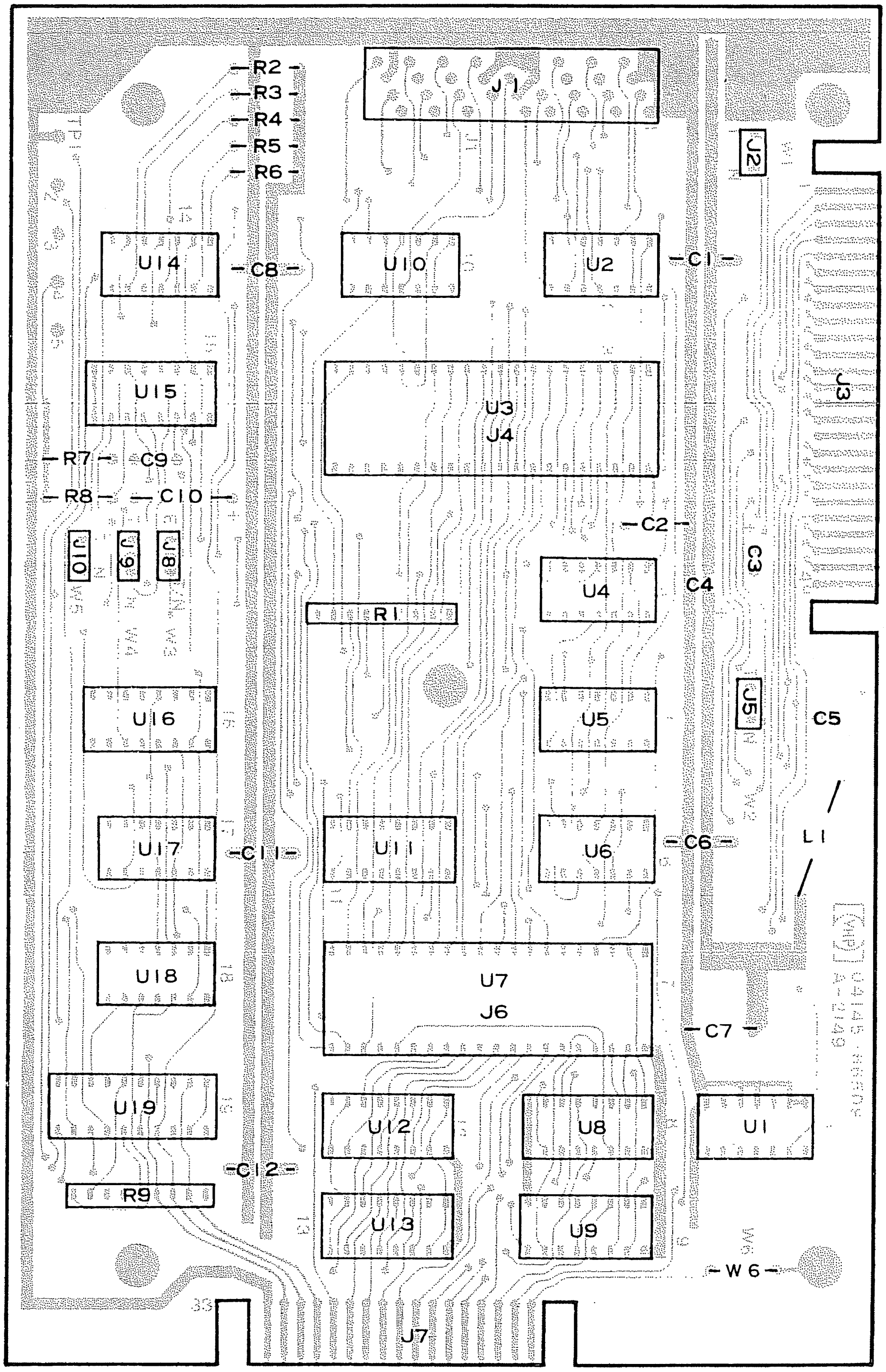


Figure 8-49. A9 HP-IB and MSU Control Board Assembly Component Locations.

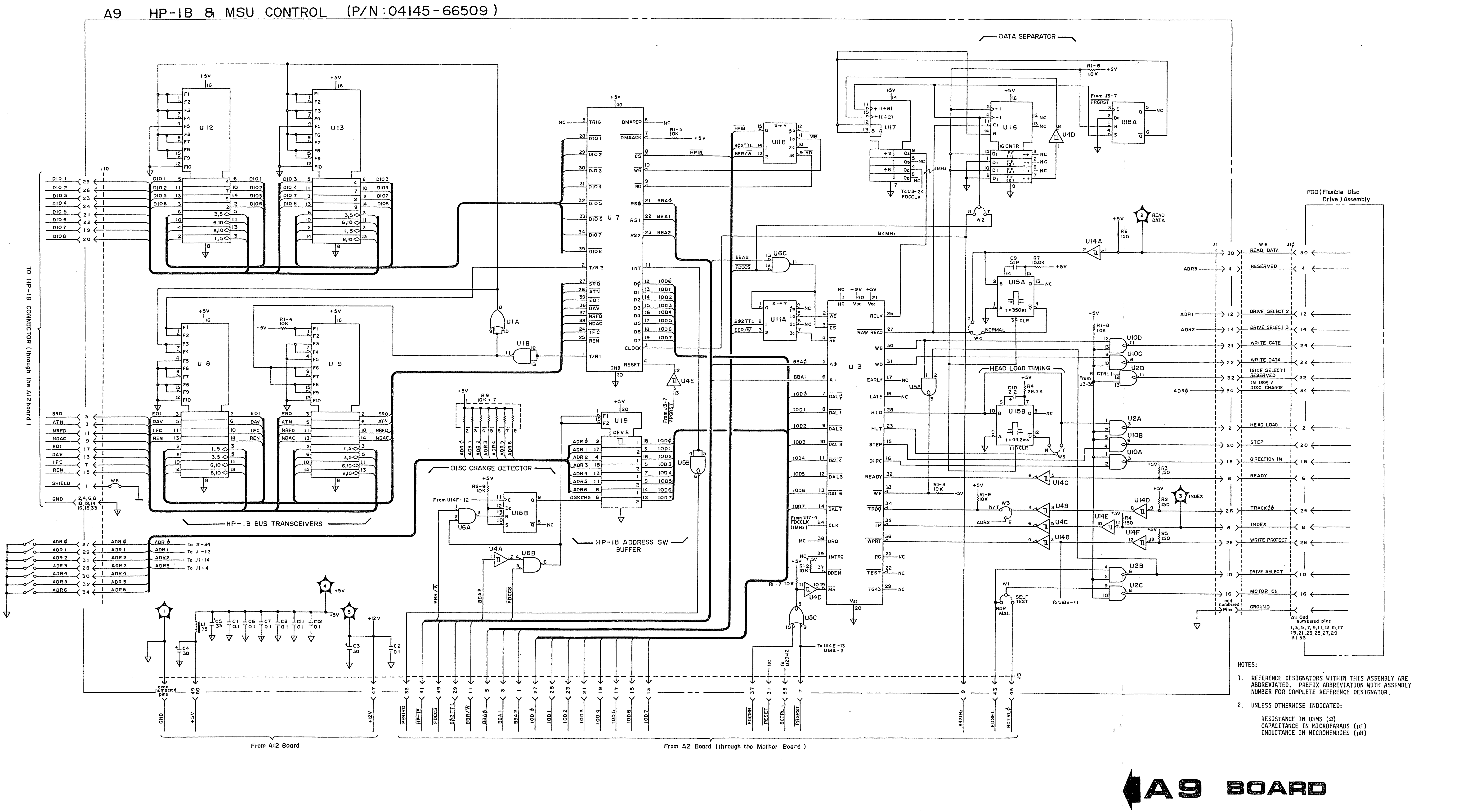


Figure 8-50. A9 HP-IB and MSU COntrol Board Assembly Schematic Diagram.

8-48. A10 KEYBOARD & DISPLAY CONTROL BOARD

8-49. The A10 board is divided into three sections: key control section, LED control section, and RPG control section.

[Key Control Section]

Figure 8-51 shows a simplified block diagram of the key control section. U3B and U10 count down the 10kHz keyboard clock signal. U10 outputs three signals: ROW1 (2.5kHz), ROW2 (1.25kHz) and ROW4 (625Hz). U11 decodes the ROW1, ROW2 and ROW4 signals into the key scan signals (KRW0 - KRW7), which are applied to each row of the key matrix. If one of the keys in the key matrix is pressed, U9 encodes the column data into a 3-bit signal. The MPU reads the row (U7) and column (U8) data to determine which key is being pressed.

The arrow keys and the FAST key are not included in the key matrix because more than one of these keys can be pressed at the same time. When one of these keys is pressed, U1 disables the key matrix and data for arrow keys and FAST key are read by the microprocessor.

[RPG Control Section]

The RPG (Rotary Pulse Generator), when rotated, outputs pulses indicating the direction and number of rotations. U3 outputs direction data and U4 outputs the number of rotations.

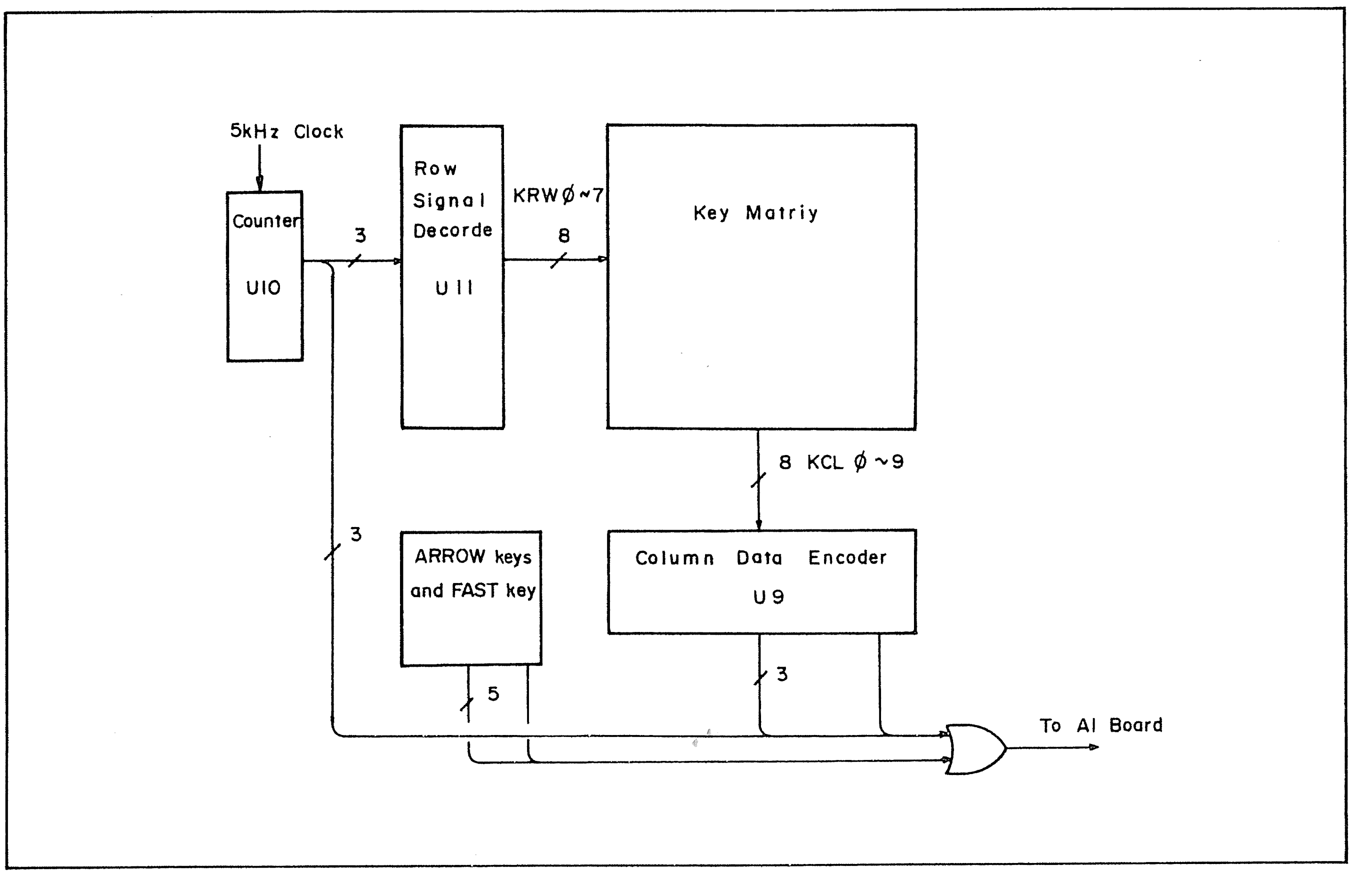


Figure 8-51. Block Diagram of Key Control Section.

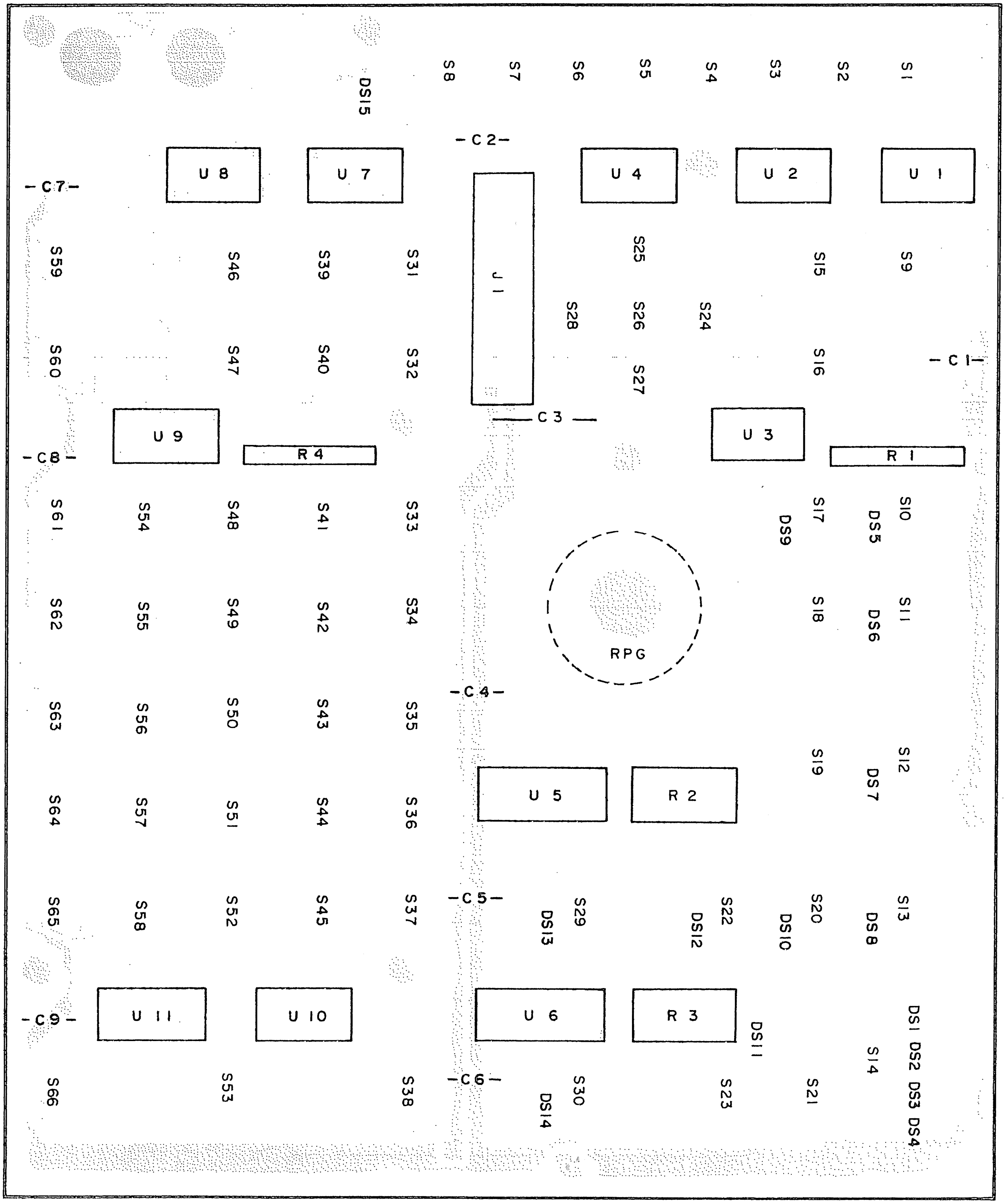
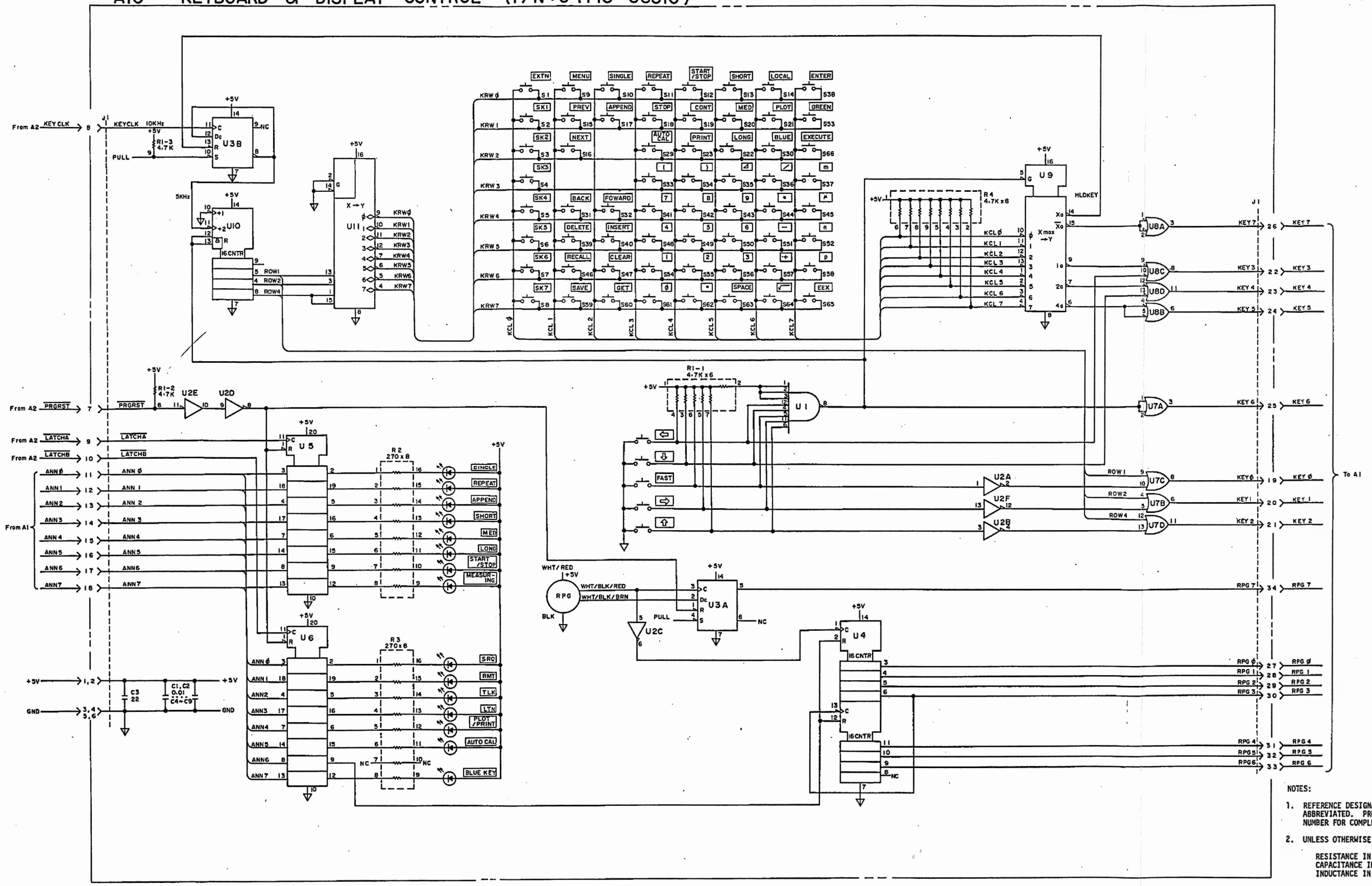


Figure 8-52. A10 Keyboard and Display Control Board Assembly Component Locations.

A10 KEYBOARD & DISPLAY CONTROL (P/N:04145-66510)



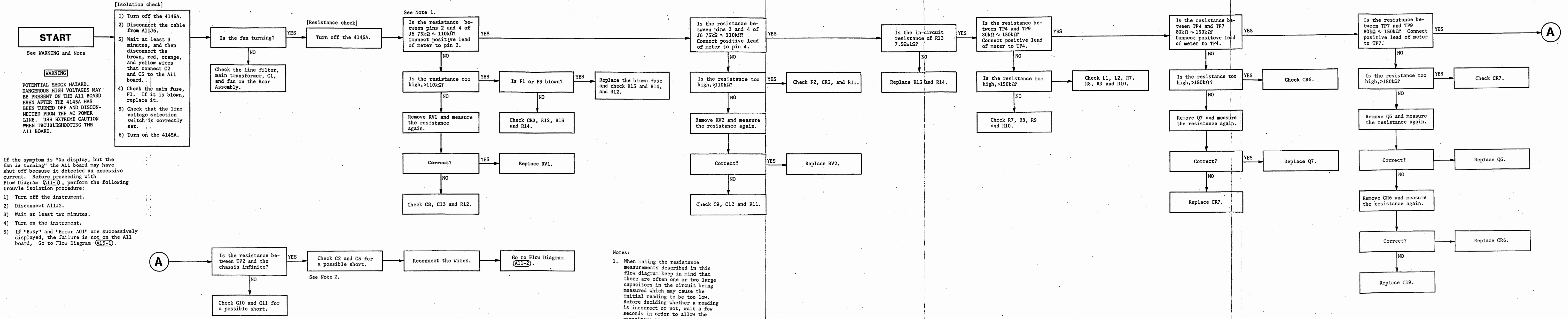
NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.

2. UNLESS OTHERWISE INDICATED:

RESISTANCE IN OHMS (Ω)
CAPACITANCE IN MICROFARADS (μF)
INDUCTANCE IN MICROHENRIES (μH)

Flow Diagram (A11 - 1)



WARNING

POTENTIAL SHOCK HAZARD. DANGEROUS HIGH VOLTAGES MAY BE PRESENT ON THE A11 BOARD EVEN AFTER THE 4145A HAS BEEN TURNED OFF AND DISCONNECTED FROM THE AC POWER LINE. USE EXTREME CAUTION WHEN TROUBLESHOOTING THE A11 BOARD.

Note: If the symptom is "No display, but the fan is turning" the A11 board may have shut off because it detected an excessive current. Before proceeding with Flow Diagram (A11-1), perform the following trouvle isolation procedure:

1) Turn off the instrument.
2) Disconnect A11J2.
3) Wait at least two minutes.
4) Turn on the instrument.
5) If "Busy" and "Error A01" are successively displayed, the failure is not on the A11 board, Go to Flow Diagram (A15-1).

Notes:

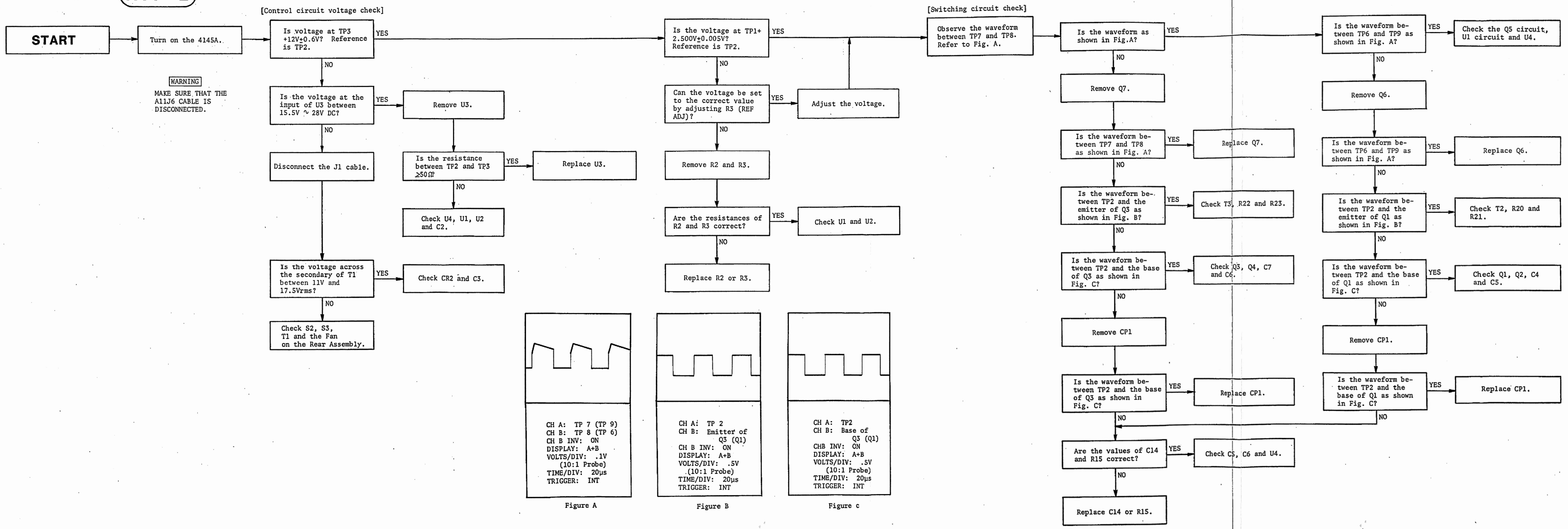
1. When making the resistance measurements described in this flow diagram keep in mind that there are often one or two large capacitors in the circuit being measured which may cause the initial reading to be too low. Before deciding whether a reading is incorrect or not, wait a few seconds in order to allow the capacitors to charge.
2. C2 and C3 are mounted on Rear Assembly A. Refer to Figure 8-6.

A10 BOARD

Figure 8-53. A10 Keyboard and Display Board Assembly Component Locations.

Figure 8-54. A11 Board Troubleshooting Flow Diagram (Sheet 1 of 2).

Flow Diagram (A11 - 2)



8-50. A11 SWITCHING POWER SUPPLY BOARD

8-51. The switching power regulator on the A11 board constructs a light weight, powerful dc power supply, upgrading the mobility of the instrument. When the instrument is turned on, ac line voltage is applied to CR3 before being stepped down to the required voltages by T1. In 220/240V operation, the CR3 circuitry acts as a bridged rectifier (Figure 8-55 (a)). In 100/120V operation, the line voltage selector switches transform the configuration of the CR3 circuitry into a voltage doubler which provides a dc voltage almost equal to that obtained in 220/240V operation (Figure 8-55 (b)).

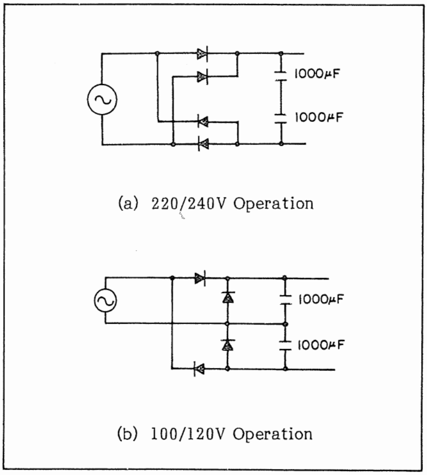


Figure 8-55. Rectifier Circuit.

RV1 and RV2 (varisters) protect the instrument from excessive voltage that may blow the power fuse. To suppress turn-on surge current, K1 allows R13 and R14 to restrict the line current for a brief period after the instrument is turned on.

The high dc voltage from the rectifier circuit is periodically chopped by Q6 and Q7, which are alternately turned on and off at approx. 20kHz by the switching controller, U4. (Figure 8-56)

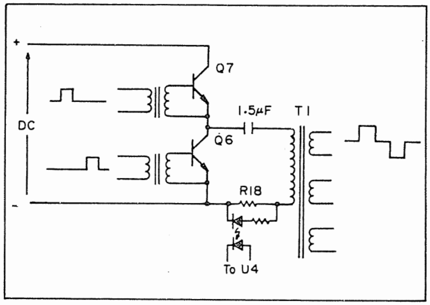


Figure 8-56. Switching Circuit.

U4 also controls the duty cycle of the pulses at the T1 primary by monitoring the DC output from CR4. If the monitored DC is too high, U4 decreases the duty cycle of the Q6 and Q7 switching pulses; if the monitored DC is too low, U4 increases the duty cycle. Thus, the DC component of T1 output pulses is kept constant for all values of AC line voltage.

If excessive current flows through R18, U4 will detect it via CP1 optocoupler and stop generating the Q6 and Q7 switching pulses, thus shutting off the power supply.

DC power for U4 is provided by CR2, U3 and C3. C3 is large—2200µF—because U4 must be turned off only after all other circuits are off when the 4145A is turned off.

U1A and U1B monitor the dc voltage output from CR3. See Figure 8-57. When the power is removed, U1A sends a RESET signal to the MPU to reset the entire instrument. If the power loss is of a short duration, however, the instrument will recover and will display "Recovered from power down ! " These brief power failures are detected by U1B.

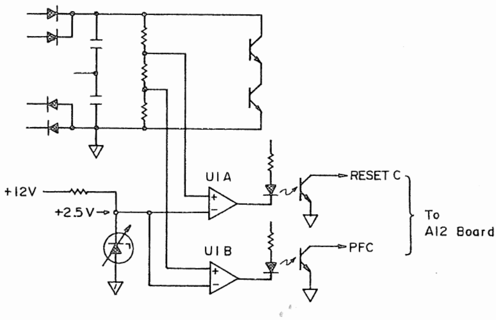


Figure 8-57. Power Loss Detection Circuit.

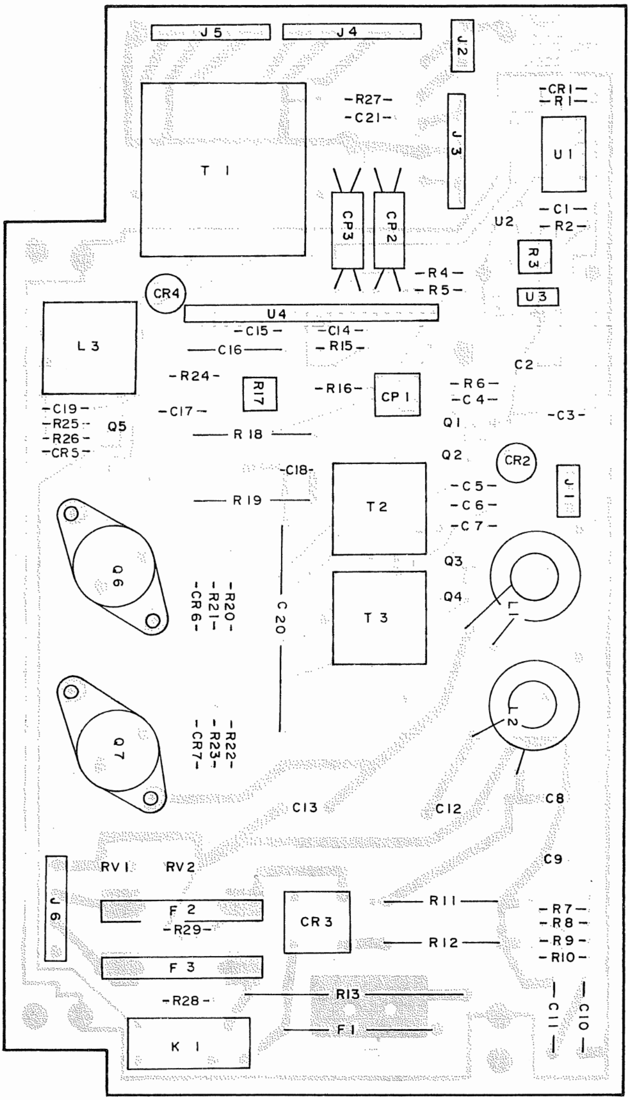
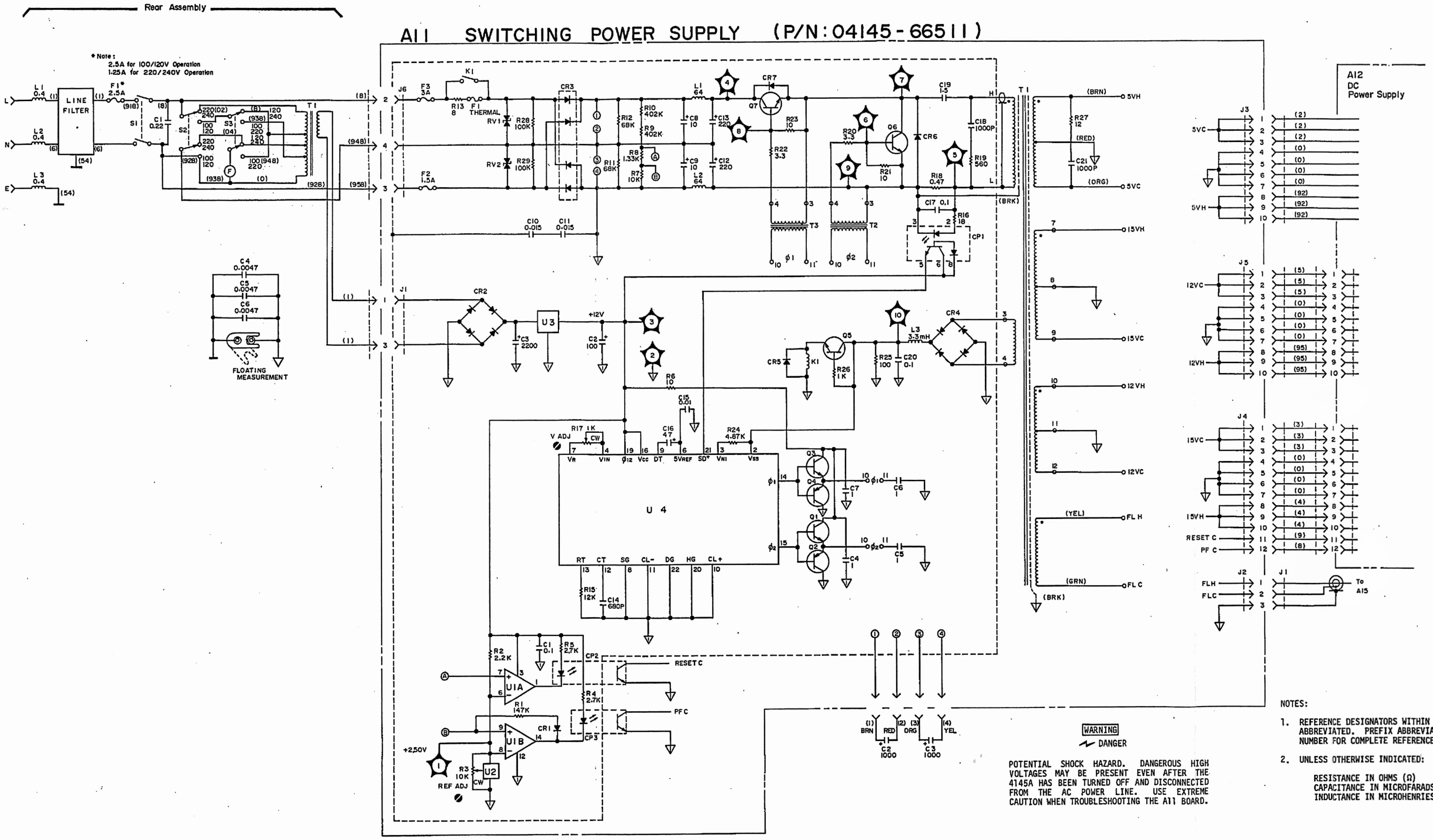


Figure 8-58. A11 Switching Power Supply Board Assembly Component Locations.

A11 SWITCHING POWER SUPPLY (P/N:04145-66511)



WARNING

DANGER

POTENTIAL SHOCK HAZARD. DANGEROUS HIGH VOLTAGES MAY BE PRESENT EVEN AFTER THE 4145A HAS BEEN TURNED OFF AND DISCONNECTED FROM THE AC POWER LINE. USE EXTREME CAUTION WHEN TROUBLESHOOTING THE A11 BOARD.

NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
2. UNLESS OTHERWISE INDICATED:

   RESISTANCE IN OHMS (Ω)
   CAPACITANCE IN MICROFARADS (μF)
   INDUCTANCE IN MICROHENRIES (μH)

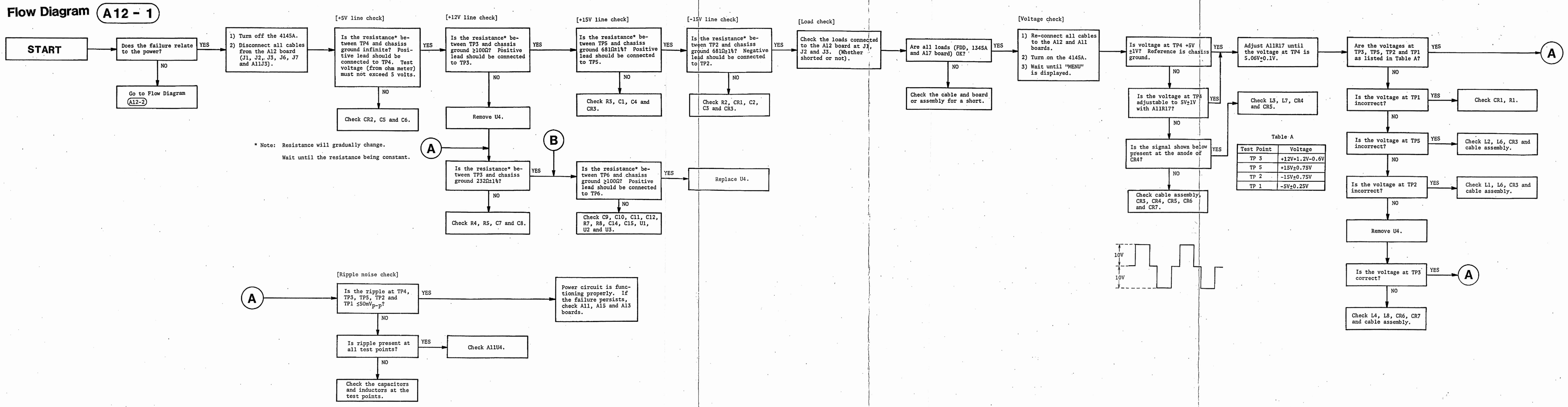


Table A

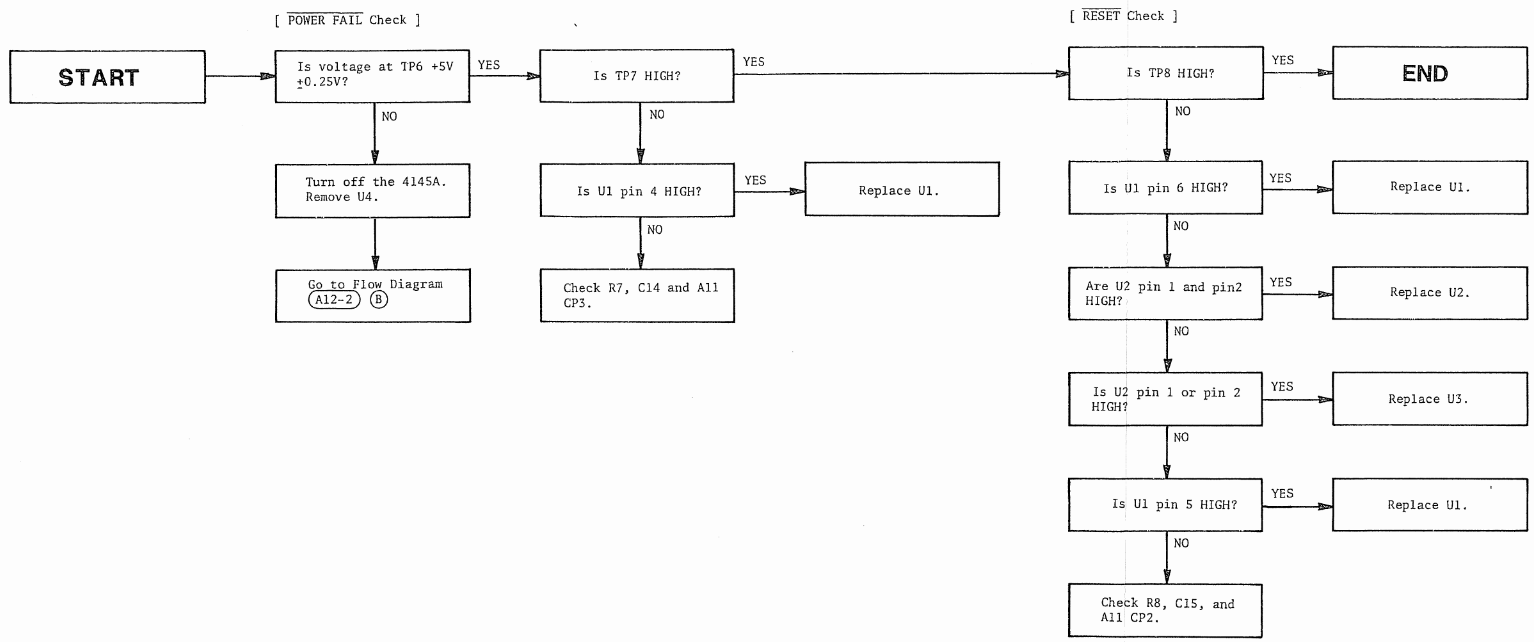
Test Point	Voltage
TP 3	+12V+1.2V-0.6V
TP 5	+15V±0.75V
TP 2	-15V±0.75V
TP 1	-5V±0.25V

A11 BOARD

Figure 8-59. A11 Switching Power Supply Board Assembly Schematic Diagram.

Figure 8-60. A12 Board Troubleshooting Flow Diagram (Sheet 1 of 2).

Flow Diagram (A12 - 2)



A12 Troubleshooting Flow Diagram

SEE INSIDE

Figure 8-60. A12 Board Troubleshooting Flow Diagram (Sheet 2 of 2).

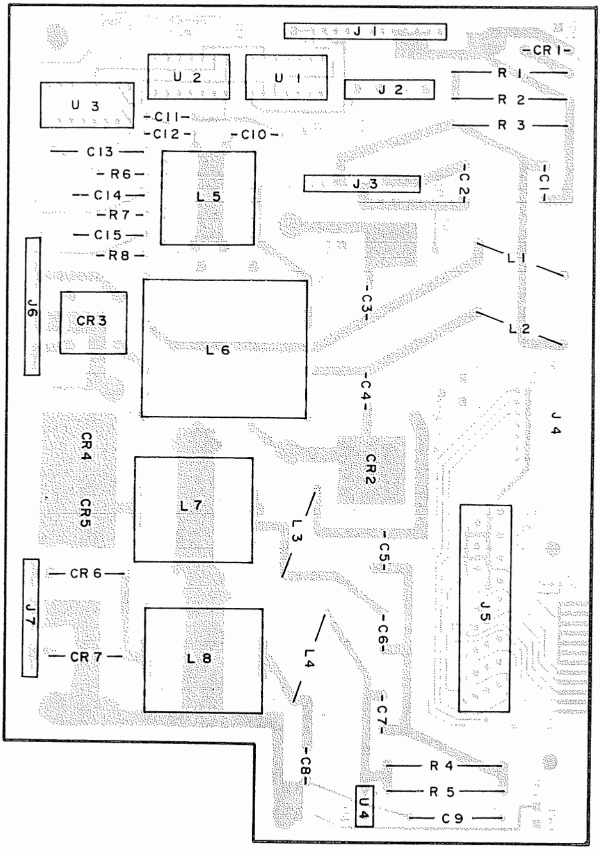
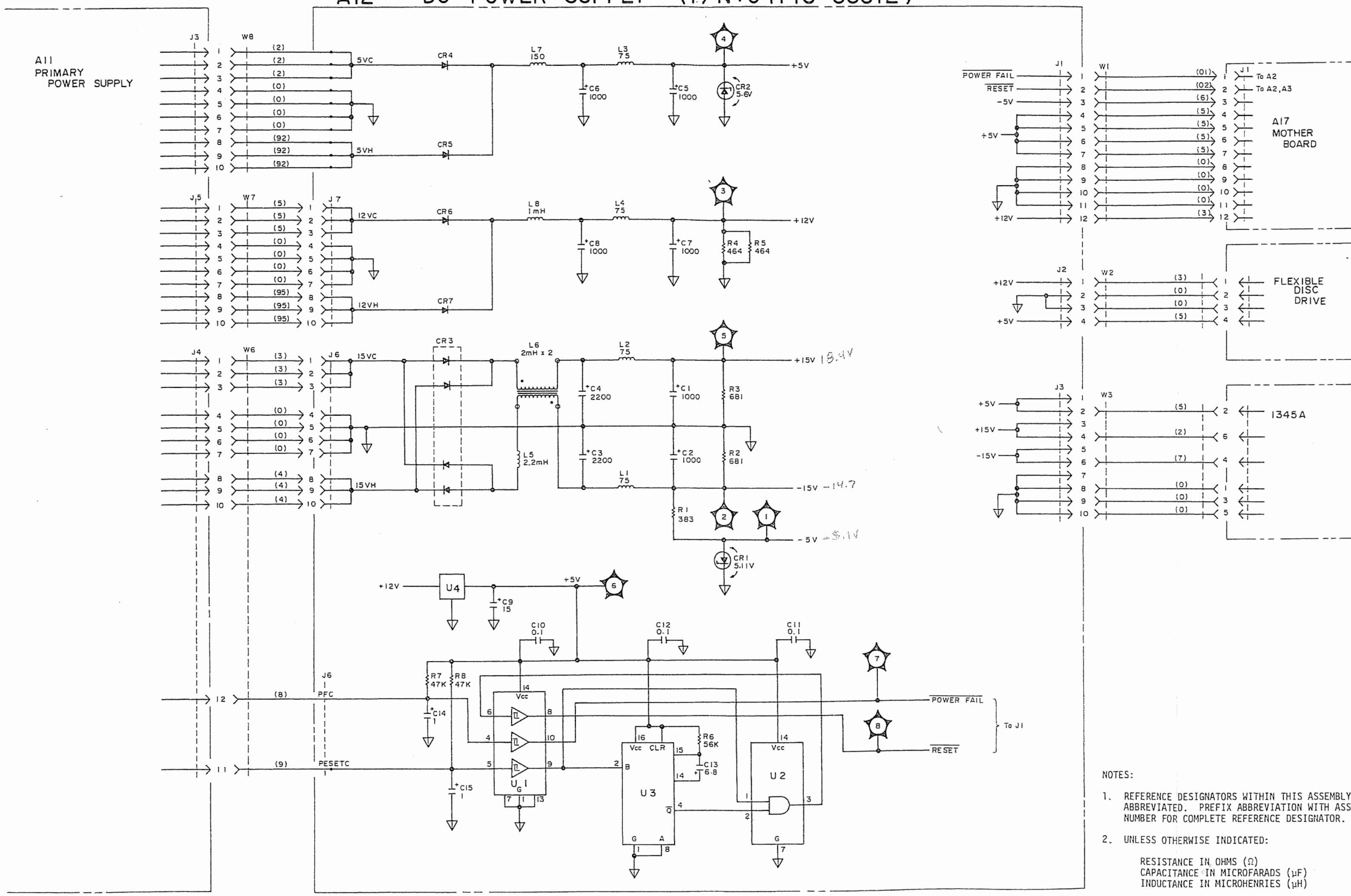


Figure 8-61. A12 DC Power Supply Board Assembly Component Locations.

A12 DC POWER SUPPLY (P/N:04145-66512)



NOTES:

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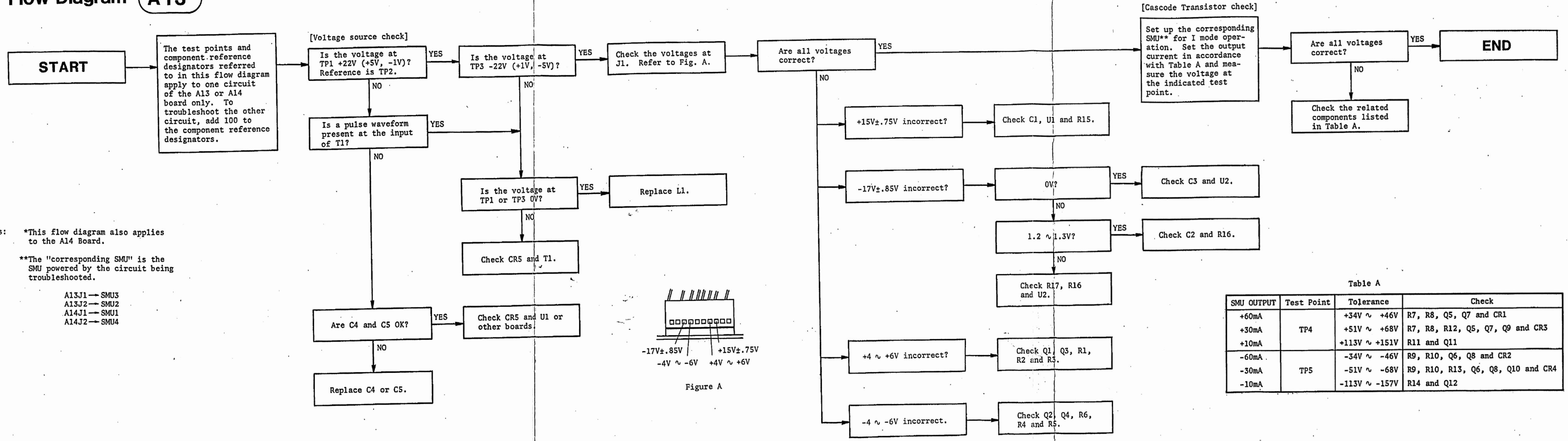
2. UNLESS OTHERWISE INDICATED:

   RESISTANCE IN OHMS (Ω)
   CAPACITANCE IN MICROFARADS (μF)
   INDUCTANCE IN MICROHENRIES (μH)

Flow Diagram (A13)



Notes: *This flow diagram also applies to the A14 Board.

**The "corresponding SMU" is the SMU powered by the circuit being troubleshooted.

A13J1 — SMU3
A13J2 — SMU2
A14J1 — SMU1
A14J2 — SMU4

Figure A

Table A

SMU OUTPUT	Test Point	Tolerance	Check
+60mA		+34V ∿ +46V	R7, R8, Q5, Q7 and CR1
+30mA	TP4	+51V ∿ +68V	R7, R8, R12, Q5, Q7, Q9 and CR3
+10mA		+113V ∿ +151V	R11 and Q11
-60mA		-34V ∿ -46V	R9, R10, Q6, Q8 and CR2
-30mA	TP5	-51V ∿ -68V	R9, R10, R13, Q6, Q8, Q10 and CR4
-10mA		-113V ∿ -157V	R14 and Q12

A12 BOARD

SEE INSIDE

Figure 8-62. A12 DC Power Supply Board Assembly Schematic Diagram.

Figure 8-63. A13 Board Troubleshooting Flow Diagram.

8-52. A13 SMU POWER SOURCE BOARDS

8-53. Each A13 board provides dc power for two of the four SMUs. The output stage of the power amplifier on the SMU board is connected to the A13 board (Refer to Figure 8-44). As for the positive voltage circuitry, Q1 is biased by R2 and R3. Initially Q1, Q7 and Q11 are on, and Q3, Q5 and Q9 are off. So +130V is applied to the collector of Q1. Q5 and Q9 change the voltage applied to Q1 according to output current to obtain an optimum power consumption. Figure 8-64 shows partial schematics. Change sequence is as follows:

(1) When I is low, Q11 is biased by R11 and held on, and dc power is provided from +130V.

(2) If I increases, the voltage drop across R12 also increases, turning on Q9 and turning off Q11.

(3) DC power is then provided from the +60V supply.

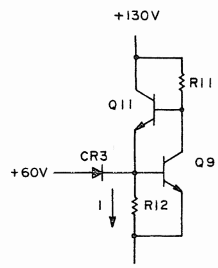


Figure 8-64. Voltage Change Sequence.

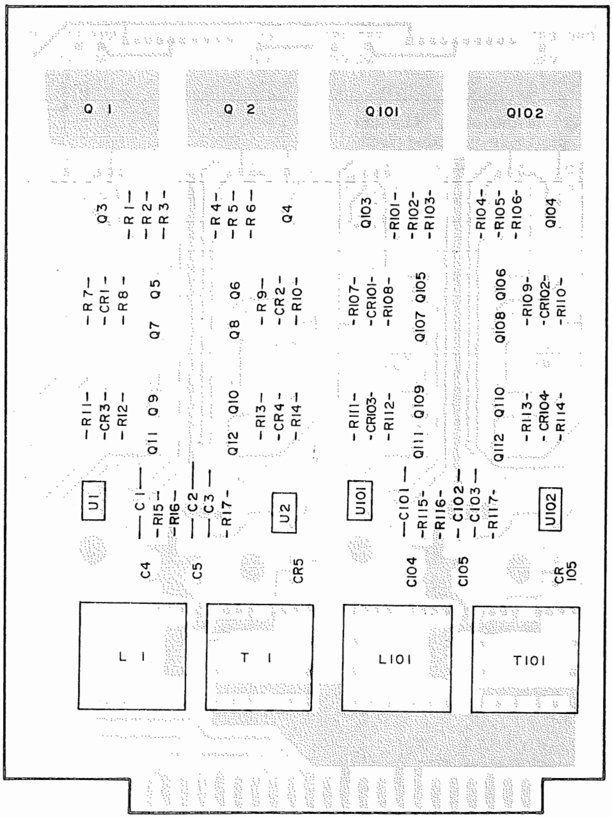
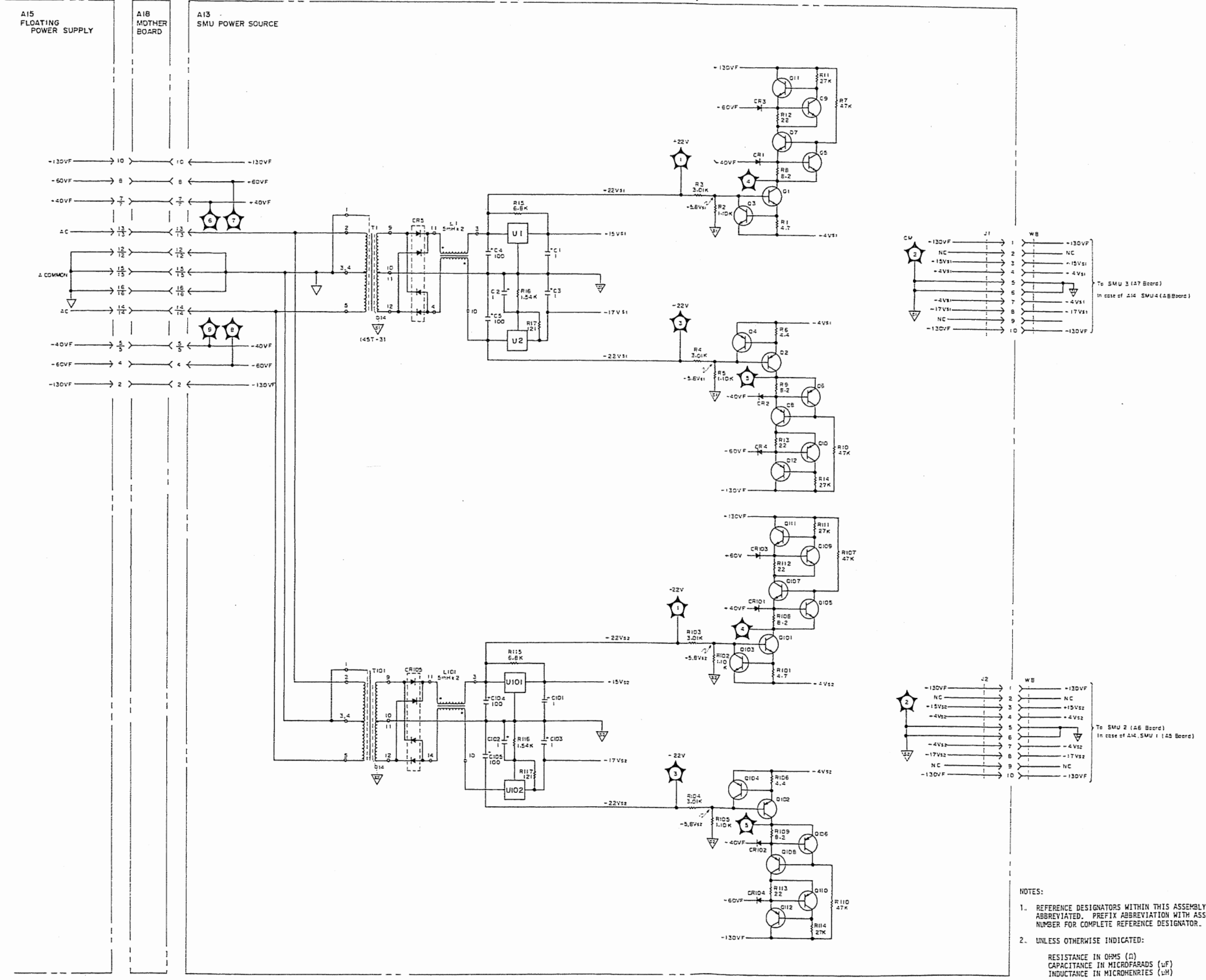


Figure 8-65. A13 SMU Power Source Board Assembly Component Locations.

A13 (A14) SMU POWER SOURCE (P/N:04145-66513)



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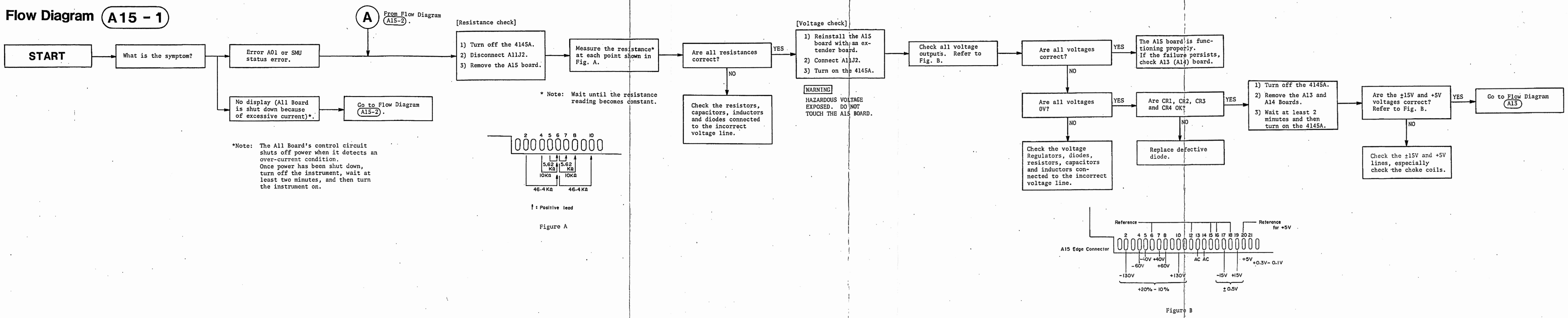
2. UNLESS OTHERWISE INDICATED:

   RESISTANCE IN OHMS (Ω)
   CAPACITANCE IN MICROFARADS (uF)
   INDUCTANCE IN MICROHENRIES (uH)

Flow Diagram (A15 - 1)



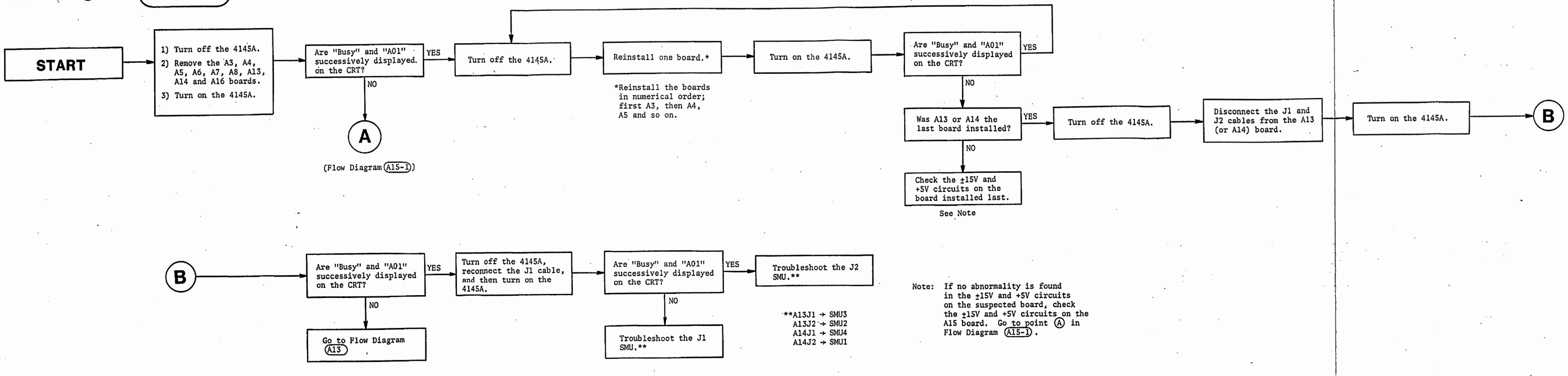
A13 BOARD

SEE INSIDE

Figure 8-66. A13 SMU Power Source Board Assembly Schematic Diagram.

Figure 8-67. A15 Board Troubleshooting Flow Diagram (Sheet 1 of 2).

Flow Diagram (A15 - 2)



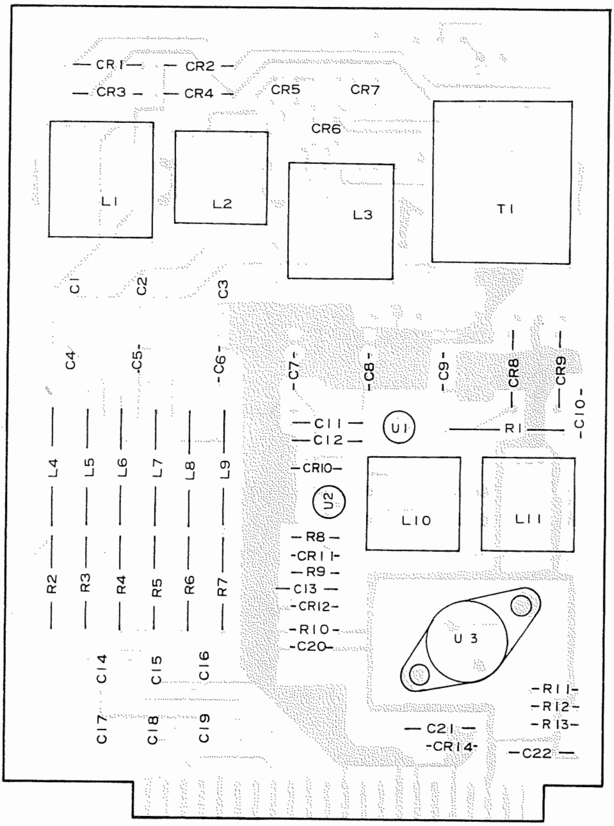
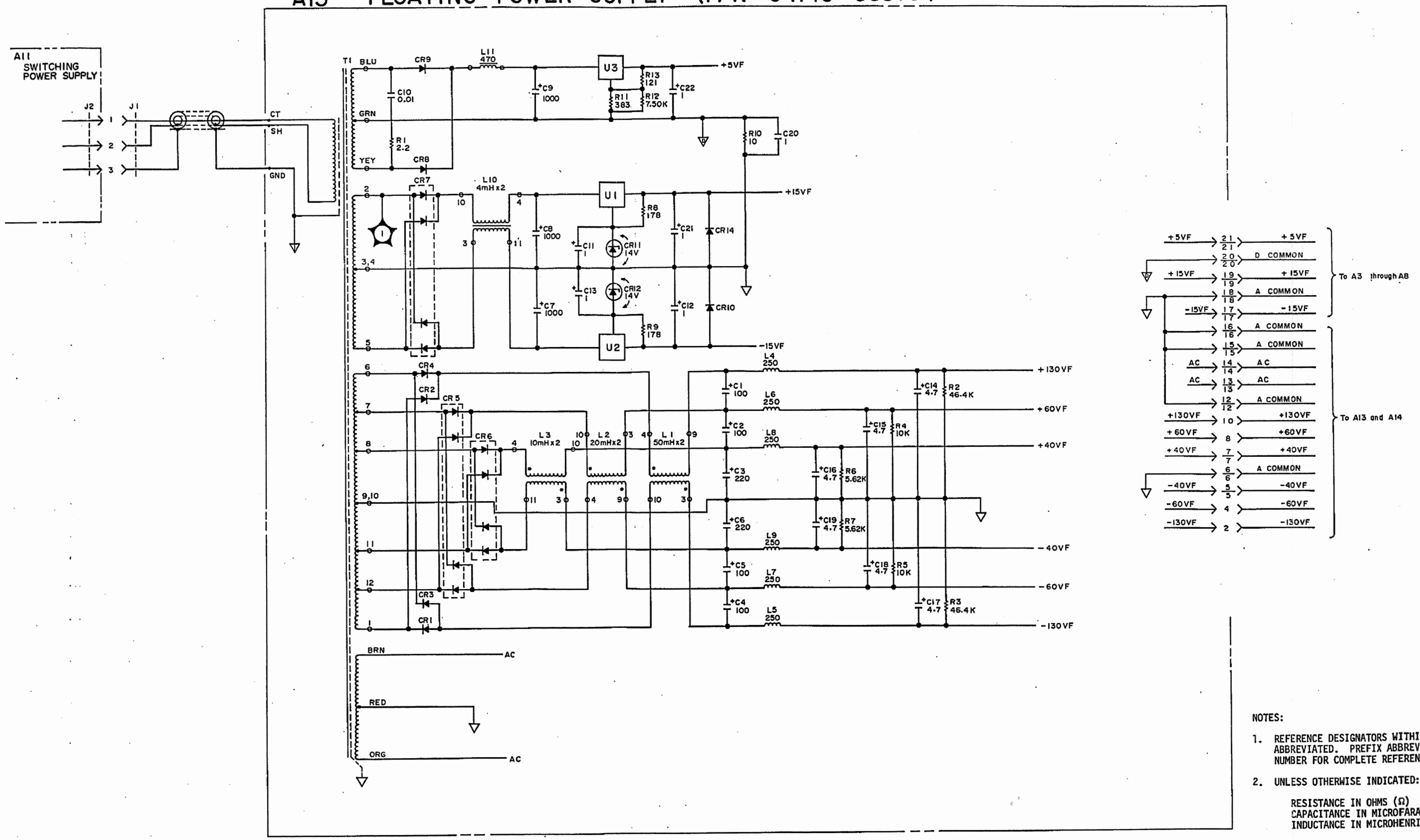


Figure 8-68. A15 Floating Power Supply Board Assembly Component Locations.

A15 FLOATING POWER SUPPLY (P/N: 04145-66515)



NOTES:

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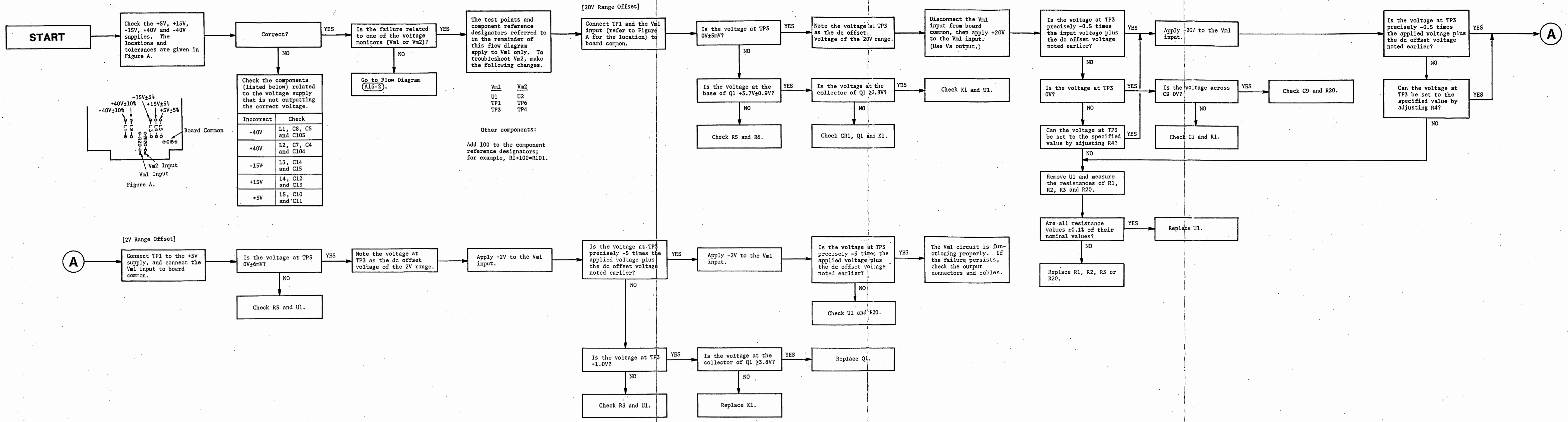
2. UNLESS OTHERWISE INDICATED:

   RESISTANCE IN OHMS (Ω)
   CAPACITANCE IN MICROFARADS (μF)
   INDUCTANCE IN MICROHENRIES (μH)

Flow Diagram (A16 - 1)



A15 BOARD

Figure 8-69. A15 Floating Power Supply Board Assembly Schematic Diagram.

Figure 8-70. A16 Board Troubleshooting Flow Diagram (Sheet 1 of 2).

Flow Diagram (A16 - 2)

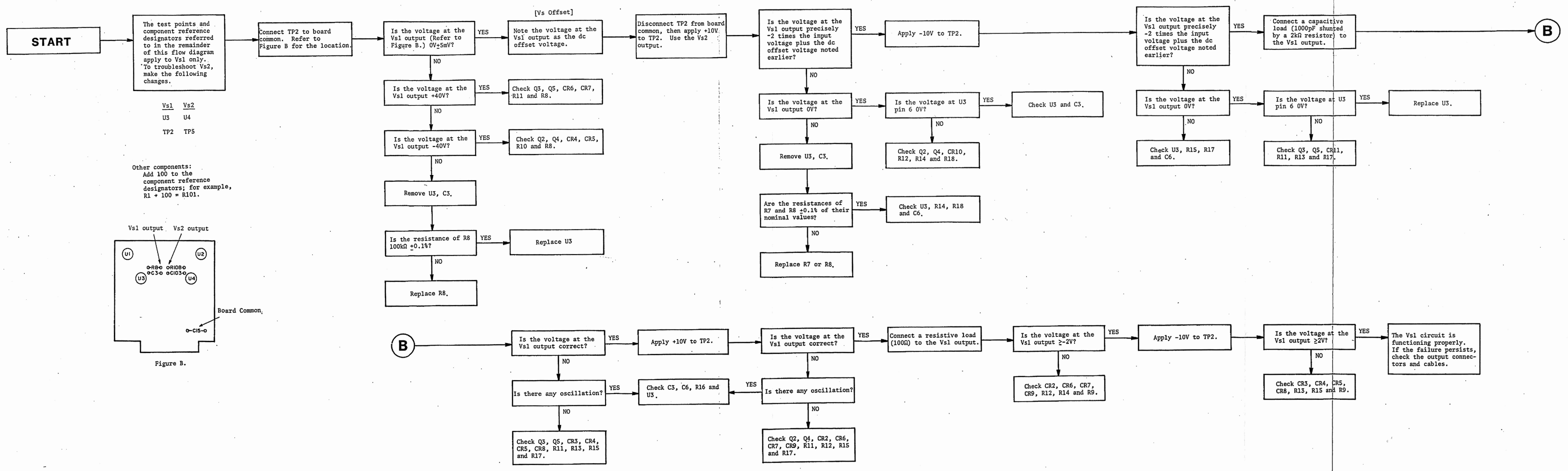


Figure B.

8-54. A16 Vs/Vm BOARD

8-55. The A16 board contains two voltage sources and two voltage monitors. Figure 8-71 shows a simplified block diagram of one of the voltage sources. Each voltage source is simply an inverting X2 DC amplifier that amplifies the reference voltages supplied from the A4 board. Figure 8-72 shows a block diagram of one of the voltage monitors. Each voltage monitor, like the voltage sources, is an inverting DC amplifier. Gain, however, is determined by the input voltage and is controlled by the A3 microprocessor. On the 2 volt range, gain is X5; on the 20 volt range, gain is X .5.

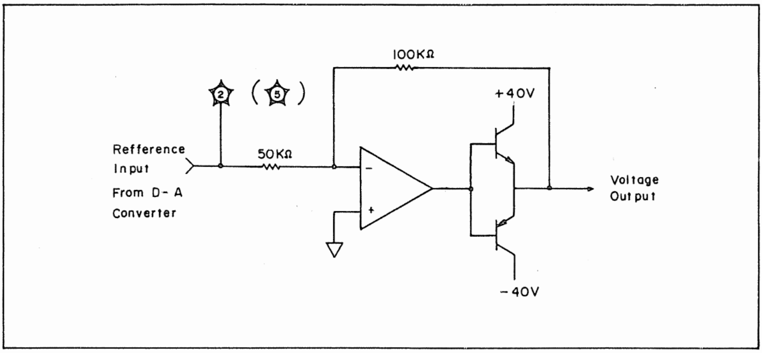


Figure 8-71. Vs Block Diagram.

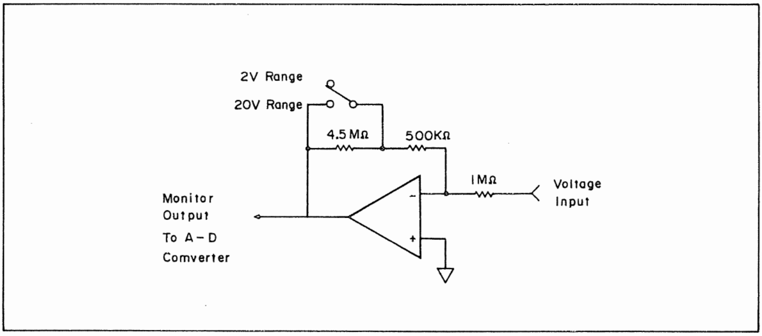


Figure 8-72. Vm Block Diagram.

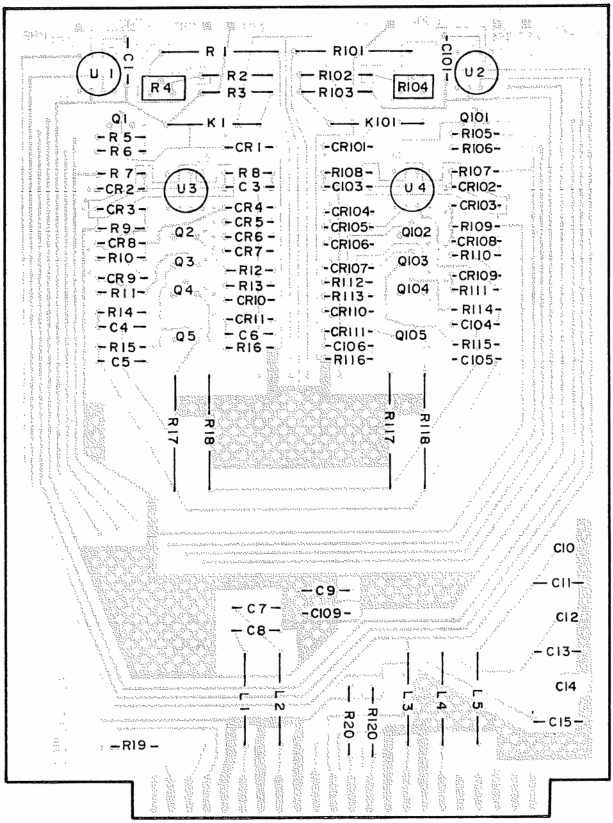
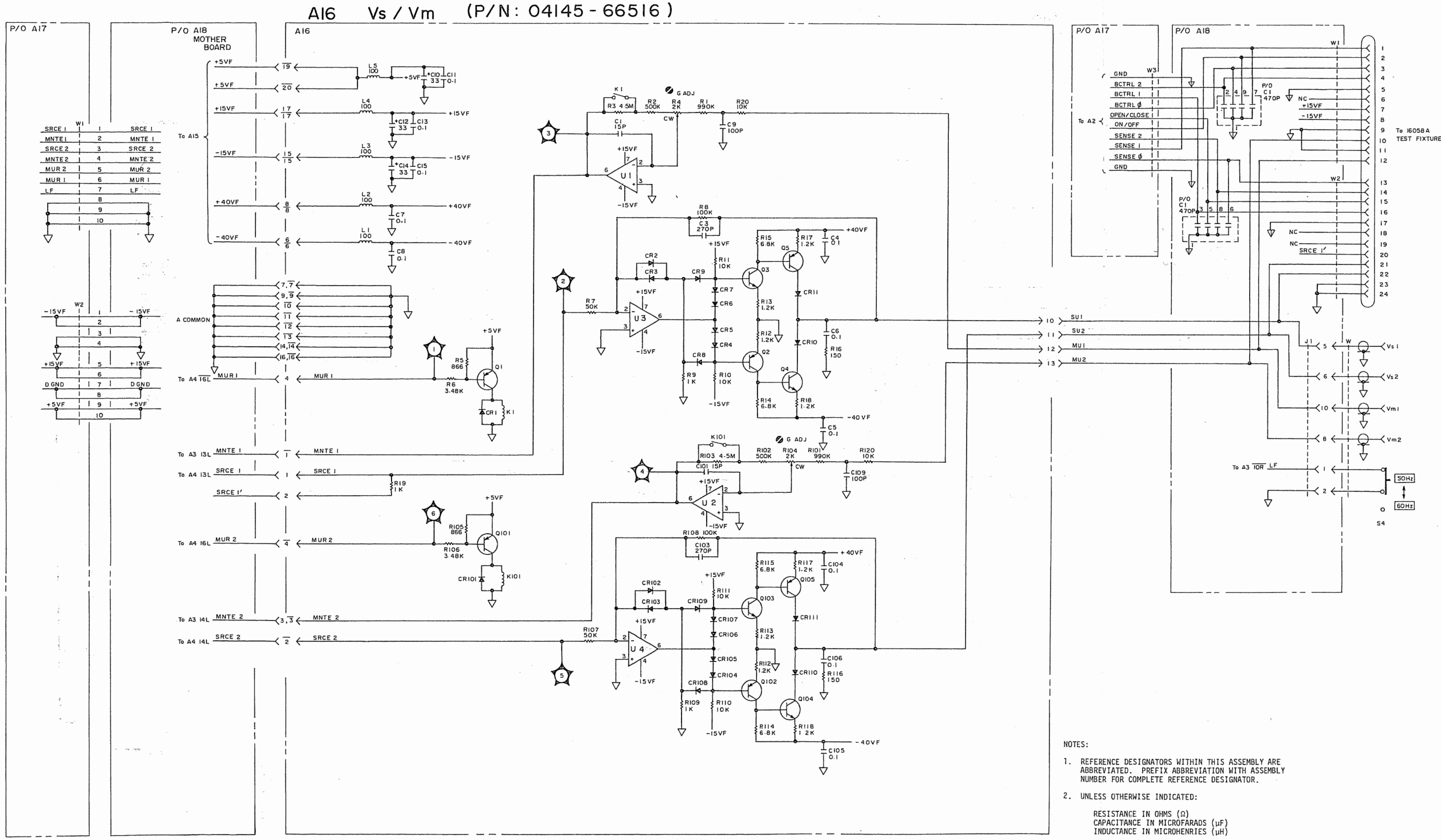


Figure 8-73. A16 Vs/Vm Board Assembly Component Locations.



NOTES:

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2. UNLESS OTHERWISE INDICATED:

   RESISTANCE IN OHMS (Ω)
   CAPACITANCE IN MICROFARADS (μF)
   INDUCTANCE IN MICROHENRIES (μH)

A16 BOARD

Figure 8-74. A16 Vs/Vm Board Assembly Schematic Diagram.